TECHNICAL MANUAL

OPERATION and MAINTENANCE

QS SERIES OF SOLID STATE DC POWER SUPPLIES

NOVEMBER, 1965

ac-dc power supplies and instrumentation

BEHLMAN-INVAR ELECTRONICS CORP.

1723 CLOVERFIELD BLVD.
SANTA MONICA, CALIF.

REPRESENTATIVES IN ALL PRINCIPAL CITIES AND CANADA

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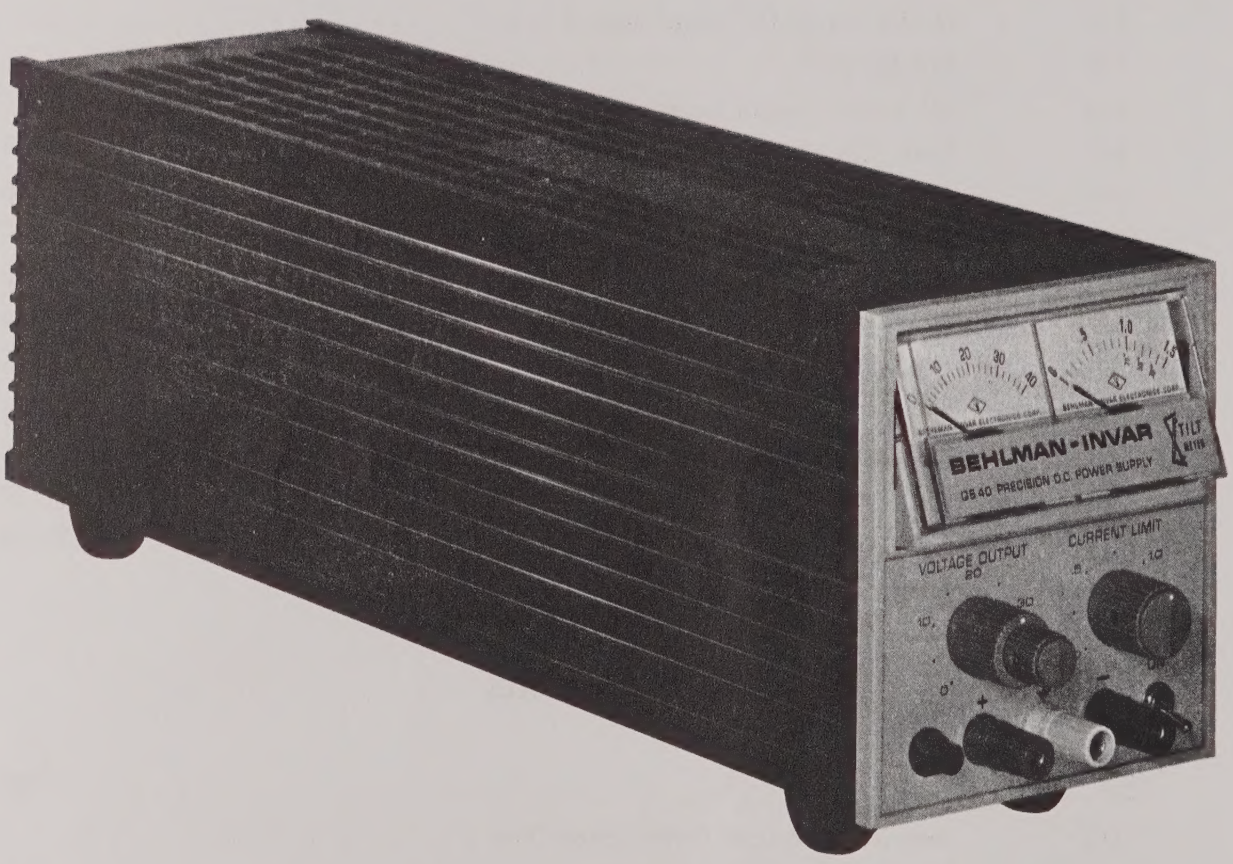


Figure 1-1. Model QS 40 DC Power Supply

SECTION 1

DESCRIPTION AND SPECIFICATIONS

1.1 INTRODUCTION

1.1.1 This manual provides a general description, theory of operation, and operating and maintenance instructions for the Behlman-Invar QS series of quarter-rack solid state DC power supplies (see Figure 1-1). In addition, this manual contains schematic diagrams and lists of replaceable parts covering all models of the QS power supplies.

1.1.2 The QS power supplies combine both high wattage and stability of operation in extremely compact packages. (The "Q" in the designation QS indicates that the power supplies are of the quarter-rack size; whereas the "S" indicates that the power supplies employ series voltage regulation.) These power supplies may be operated in either a constant voltage or a constant current mode, utilizing electronic regulation of all internal d-c voltages and liberal derating of components to achieve exceptional performance and extended service life of the regulatory components. The QS series is comprised of the following models:

Model	Outputs - Continuously Variable - at 30°C		
	Volts	Amperes	Watts
QS 5	0-5	0-6.5	0-32.5
QS 10	0-10	0-4.2	0-42
QS 20	0-20	0-2.5	0-50
QS 40	0-40	0-1.4	0-56
QS 60	0-60	0-0.96	0-57.6
QS 100	0-100	0-0.60	0-60

1.2 FEATURES

1.2.1 Tilt-Meter®. The QS power supplies are equipped with tilting meters (see Figure 1-2) to provide for ease of viewing meter indications in normal power supply positions. The meters are adjusted by pushing on the top or bottom of the meter cover.

1.2.2 Constant Voltage and Constant Current Operation. The QS power supplies provide constant voltage and constant current operation throughout their respective rated output voltage and current ranges. Constant current operation can be maintained at any point in the rated current range throughout the entire output voltage range of the power supply. The units will operate in the constant voltage mode until the output current demand exceeds a pre-selected current value, at which time the units will automatically transfer to the constant current mode of operation.

1.2.3 Remote Programming. The QS circuits provide for full-range remote programming (or control) of both the voltage and current outputs. Remote programming operation is obtained by means of resistive circuit connections to rear-mounted terminal boards. The remote voltage programming characteristic is 100 ohms/volt. Remote current programming is obtained with a 200-ohm resistor.

1.2.4 Remote Sensing. Remote sensing circuits are incorporated in the power supplies to permit power supply output voltage regulation to be controlled by means of the voltages

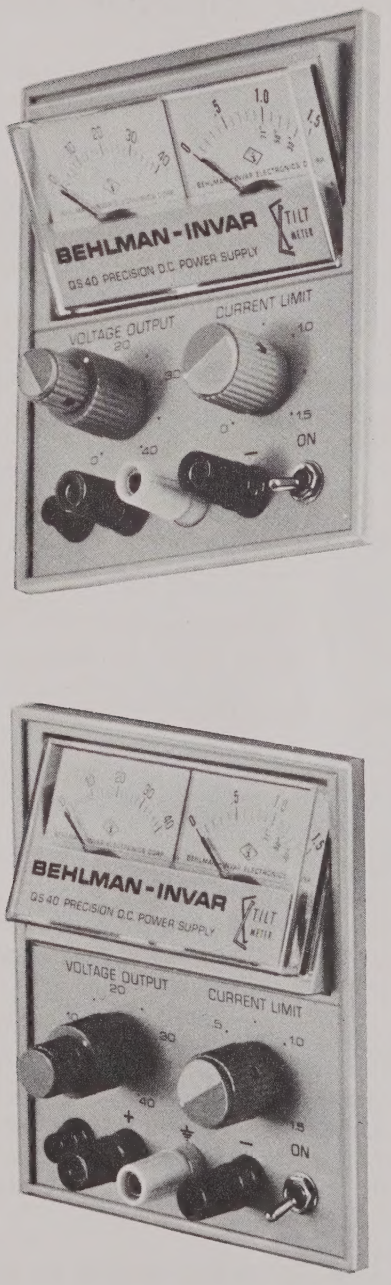


Figure 1-2. Tilt Meters®

sensed at the output loads. This feature ensures that the voltages applied to the loads remain constant within the power supply voltage regulation specifications to a maximum of one volt drop in the (output) power lines.

1.2.5 Modulation of Power Supply Output Voltage. The QS power supplies are designed to permit the injection of external modulating signals into the voltage-regulating circuits. This provision enables noise or other signals to be impressed upon the power supply output voltage to simulate operating conditions for the power supply load equipment. The external modulating signals are applied by means of convenient connections to the rear-panel terminal boards of the power supplies.

1.2.6 Parallel Operation. The QS power supplies may be operated in parallel for increased current capability. A simple interconnection provides control of both outputs from one power supply.

1.2.7 Series Operation. The QS power supplies may be operated in series for increased voltage outputs.

1.2.8 Integral Interconnections Diagrams. The operational interconnection diagrams for the QS power supplies are shown on a rear panel decal.

1.2.9 Short Circuit Protection. The QS power supplies are electronically protected and may be operated open or short circuited in any mode, observing maximum output current limitations.

1.2.10 Rack Adapter. The QS power supplies may be mounted in a rack adapter for cabinet mounting. The adapter contains multiple power outlets and accepts chassis slides.

1.3 SPECIFICATIONS AND PERFORMANCE DATA

1.3.1 Table 1-1 provides specifications and performance data for the QS series of DC power supplies.

TABLE 1-1

SPECIFICATIONS AND PERFORMANCE DATA

NOTES: Refer to paragraph 1-4 for definitions of specifications.
All measurements made at rear panel remote sense terminals.

Output Specifications:

Model	Output Voltage	Maximum Output Current - Amps at 30°C	at 50°C	at 71°C	Ripple RMS mv maximum
QS 5	0- 5 vdc	6.5	5.6	4.7	0.150
QS 10	0-10 vdc	4.2	3.6	3.0	0.170
QS 20	0-20 vdc	2.5	2.2	1.8	0.200
QS 40	0-40 vdc	1.4	1.2	1.0	0.250
QS 60	0-60 vdc	0.96	0.83	0.69	0.300
QS 100	0-100 vdc	0.60	0.52	0.43	0.400

TABLE 1-1

SPECIFICATIONS AND PERFORMANCE DATA (Continued)

		Applicable Military Specifications:	
Input Power Requirements:			
Voltage:	105-125 VAC		
Frequency:	47-480 CPS		
Current - at full load, 30°C, 115V:	1.0 AMP		
Efficiency - at full load:	54% minimum		
Environmental Specifications:		MIL-E-4970A	MIL-E-005272B
Operating temperature range:	0-71°C	Paras. 4.1.1, 4.2.3	Para. 4.1.1
Storage temperature range:	-62°C to +85°C	Paras. 4.1.1, 4.2.3	Para. 4.1.1
Warm up time:	30 minutes		
Humidity:	95%, 20-71°C, 10 days	Para. 4.3.1	Para. 4.1.1
Vibration:	2-500 cps, 1.3-5 g	Paras. 4.6.8.1, 4.6.8.2	Para. 4.7.11.2
Shock:	16 drops	Para. 4.12.6	Para. 4.6.1.1
EMI:		MIL-I-16910	
Constant Voltage Specifications:			
Line Regulation - 105-125 VAC:	0.01% or 1 MV (whichever is greater)		
Load Regulation - no load to full load:	0.01% or 1 MV (whichever is greater)		
Stability:	±10 mv/8 HRS.		
Ripple - peak to peak:	1.0 MV		
Peak Transient:	(70 x I full load) MV		
Recovery Time:	30 μSEC		
Response Time:	25 μSEC		
Output Impedance:	0.03 OHM to 1 KCPS 0.15 OHM +0.7 μH from 1 KCPS to 1 MCPS		
Temperature Coefficient - Internal voltage control:	0.02%/°C		
Temperature Coefficient - With 0° temperature coefficient external programming resistor:	0.002%/°C		
Remote Programming:	100 OHM/VOLT or 1 VOLT/VOLT		

TABLE 1-1

SPECIFICATIONS AND PERFORMANCE DATA (Continued)

Constant Voltage Specifications (Continued)	
Resolution - internal voltage control:	4.0 MV
Resolution - external programming resistor:	0.01%
Constant Current Specifications - Automatic Crossover Mode:	
Line Regulation - 105-125 VAC:	5.0 MA
Load Regulation - 0-full output voltage:	15 MA
Voltage Compliance:	0 to rated voltage
Ripple - RMS:	2.0 MA
Remote Programming - Linear, 0-full output current:	0-200 ohms
Constant Current Specifications - Precision Constant Current Mode:	
(Rear terminal connections as indicated on rear panel decal of unit.)	
Line Regulation:	1.5 MA
Load Regulation:	0.5 MA
Voltage Compliance:	0 to rated voltage
Ripple - RMS:	0.7 MA
Remote Programming - Linear, 0-full output current:	0-200 ohms
Mechanical Specifications:	
Width:	4.25 INCHES Max.
Length (overall):	16.5 INCHES Max.
Height:	4.7 INCHES Max.
Weight:	12.6 POUNDS Max.

1.4 DEFINITIONS OF POWER SUPPLY SPECIFICATIONS USED IN THIS MANUAL

1.4.1 Temperature Range: MIL-E-4970A Para. 4.1.1, 4.2.3 and MIL-E-005272B Para. 4.1.1.

1.4.1.1 Operating temperature: The range of inlet air temperature over which the power supply can be operated. The appropriate derating of output current with increasing temperature must be observed.

1.4.1.2 Storage temperature: The temperature range over which there will be no permanent damage to the power supply components.

1.4.2 Warm up Time: The time required for normal thermal disrribution to be established throughout the power supply. During this time the output may drift.

1.4.3 Humidity: MIL-E-4970 Para. 4.3.1 and MIL-E-005272B Para. 4.4.1. The exposure to high humidity and high temperature which will not degrade the power supply performance.

1.4.4 Vibration: MIL-E-4970 Para. 4.6.8.1 and 4.6.8.2, and MIL-E-005272B Para. 4.7.11.2. The level of common carrier vibration which will not cause damage to the power supply.

1.4.5 Shock: MIL-E-4970 Para. 4.12.6 and MIL-E-005272B Para. 4.6.1.1. The level of shock which may be received during bench servicing without causing damage to the power supply.

1.4.6 Electro-Magnetic Interference: MIL-I-16910. The levels of conducted and/or radiated electro-magnetic interference generated by the power supply.

1.4.7 Line Regulation: the variation in output voltage or current caused by a change in line voltage from 105 to 125 volts or from 125 to 105 volts.

1.4.8 Load Regulation: The variation in output voltage caused by a change in load current from no load to full load or from full load to no load, or, the change in output current caused by a change in load voltage from short circuit to output voltage or from maximum output voltage to short circuit.

1.4.9 Stability: The drift in output voltage over an eight hour period, during which the line, load and ambient temperature are held constant. This does not include warm up drift.

1.4.10 Ripple: The combination of all periodic and random variations around the output DC voltage; this may be expressed in RMS or peak to peak volts or amperes.

1.4.11 Recovery Time: The time required for the output voltage to return to within the regulation band after a sudden change in load. The parameters affecting this time are: 1) the effective series inductance of the output leads, 2) the time constant of the output capacitor, load resistor, and output series resistor, and 3) the time delay of the internal error amplifier. All of these items are affected by the rate of application and the magnitude of the load change. For this specification, the rate of application of the load is 10 microseconds and the magnitude of the load change is from no load to full load.

1.4.12 Response Time and Peak Transient: Peak transient is the excursion of the output voltage and response time in the time required for the output voltage to return to 37% of the peak transient after a sudden change in the load. The peak transient is caused primarily by the effective series inductance of the output leads and secondarily by the time delay of the internal error amplifier. The magnitude of the peak transient may be calculated by means of the classic formula for voltage across an inductor, namely,

$$e = L \frac{di}{dt},$$

which, for an approximately linear application of load becomes

$$\Delta E = L \frac{\Delta I}{\Delta T},$$

where ΔE is the peak transient, L is the effective series inductance, ΔI is the magnitude of the load current change and ΔT is the time required to apply the load change. Recovery time is a factor of the effective series inductance, the effective high frequency output capacitance, and the damping effect of the error amplifier, and, is proportional to the magnitude of the peak transient. For this specification, the rate of application of the load is 10 microseconds and the magnitude of the load change is from no load to full load; the maximum effective series inductance of the QS series of power supplies is 0.7 microhenries.

1.4.13 Output Impedance: The effective series impedance of the output leads of the power supply. This is measured by varying the load current approximately 10%, measuring the AC component of the load current, measuring the AC component of the output voltage, and applying the formula for impedance, which is:

$$Z = \frac{e}{i}.$$

Since the output impedance is a function of frequency, it is specified over the ranges of DC to 1 Kcps and 1 Kcps to 1 Mcps. The magnitude of the output impedance is the maximum for any frequency below the stated frequency (see Figure 1-3).

1.4.14 Temperature Coefficient: the change in output voltage as a result of a given change in temperature only. The change in output voltage of the QS power supplies is caused primarily by the temperature coefficient of the internal voltage control potentiometer. The use of a very low temperature coefficient resistor (remote programming resistor) in the place of the internal voltage control will reduce the temperature coefficient of the QS power supplies by 10 times; for this reason the temperature coefficient is specified for both conditions. If other than a zero temperature coefficient programming resistor is employed, the temperature coefficient of the resistor must be added to the temperature coefficient specified for the power supply.

1.4.15 Remote Programming: The control of the output voltage or current with an external resistor or external voltage. This specifies the variation in control parameter for a given change in output.

1.4.16 Resolution: The minimum controlled step change in the output. Since this is a function of the resolution of the control parameter, it is specified for both internal and remote programming modes.

1.4.17 Voltage Compliance: The output voltage range of a power supply operating in the constant current mode.

1.4.18 Precision Constant Current Mode: The mode of operation for constant current only, which, through rear panel interconnections, removes all internal current flow not absolutely required; i.e., the voltmeter. This permits regulation to the limits of the error amplifier gain.

1.4.19 Test Conditions. The instrumentation and measurement techniques employed in the testing of the QS power supplies, as in the testing of any precision electronic equipment, require both careful selection and application. The accuracies of the measurement and display functions of the test equipment employed must, in all pertinent aspects, exceed the electrical design tolerances of the power supply undergoing evaluation. For example, the observation and measurement of the amplitude of transient spikes with durations of less than 1 microsecond requires use of a very wide band oscilloscope; a conventional oscilloscope with a 100-KC bandwidth being completely inadequate for the task. A frequently overlooked contributor to erroneous measurements is the selection of a test instrument having an accuracy adequate for the performance of certain measurements, but having a long term stability less than that of the power supply characteristic being measured. In this case, the recorded results of a 10-hour

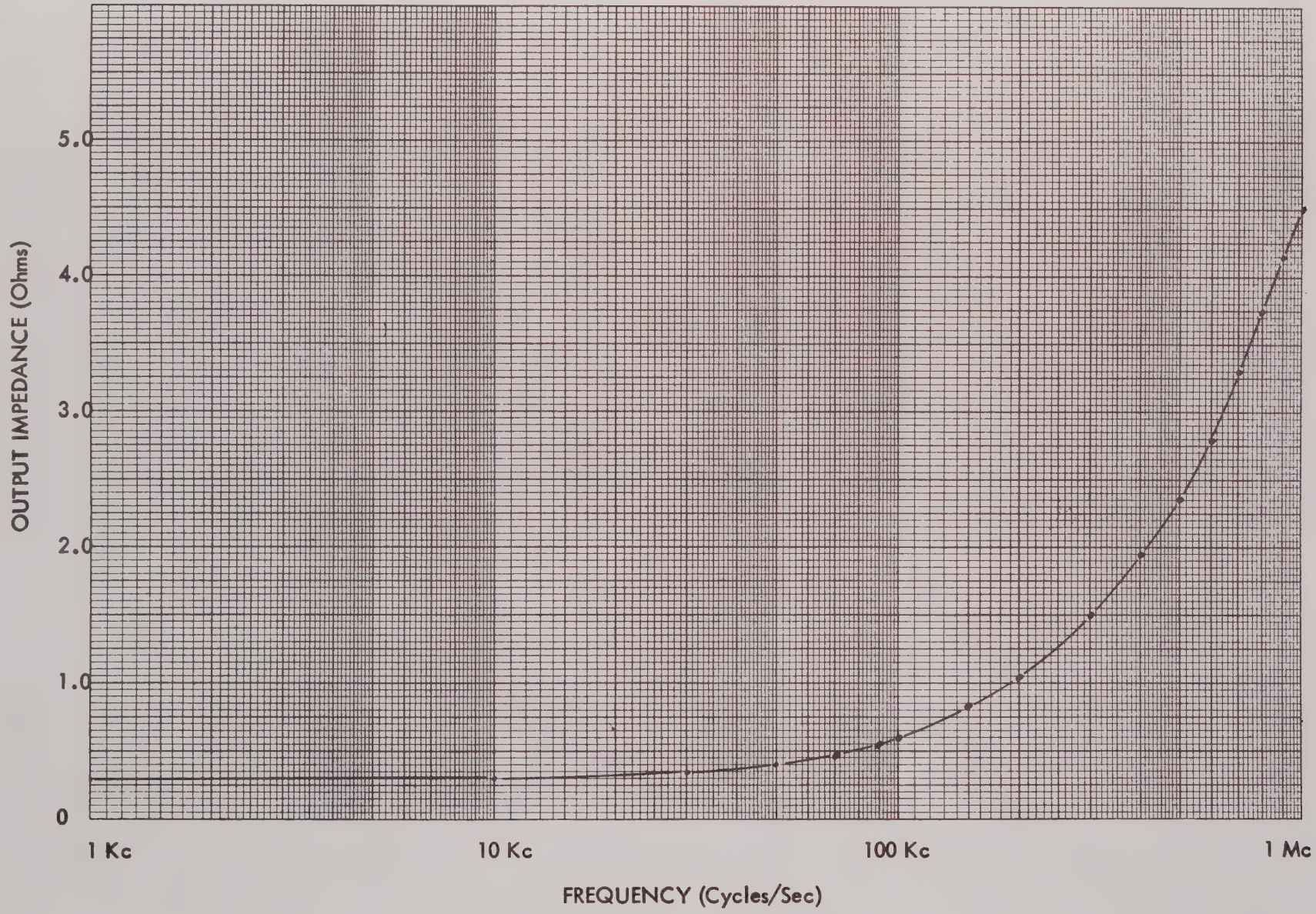


Figure 1-3. QS Series Output Impedance Characteristic

test may appear to indicate a serious instability of the power supply characteristic being evaluated, whereas the actual cause of the apparent instability lies within the test equipment.

1.4.20 Measurement techniques must be devised to minimize the effects of external influences upon measurement results. Noise and external a-c signals may be impressed upon voltages being measured as the result of pickup by over-long test leads, or by ground loops existing due to a common ground connection between the a-c power inputs to the power supply and to the test equipment. Poor test lead connections to the power supply output can result in serious measurement errors as the result of the introduction of resistances to the test circuit which far exceed the output impedance of the power supply.

SECTION 2

CIRCUIT DESCRIPTION

2.1 GENERAL FUNCTIONAL DESCRIPTION

2.1.1 The basic circuit of the QS series solid-state DC power supplies is shown in the block diagram of Figure 2-1 (also see the schematic diagram, Figure 4-1). Principal circuits of the power supply are as follows: the main power supply rectifier, a series (or pass) regulator, current error and voltage error amplifier stages, and auxiliary power supply and reference voltage circuits. The power supply regulatory circuits provide a constant output voltage at any voltage level selected within the rated, continuously variable output voltage range. A constant output current level can be maintained at any point selected in the rated, continuously variable output current range throughout the output voltage range of the power supply. At any time that the output current demand exceeds the established maximum value, the regulatory circuits then function to adjust the voltage applied to the power supply load so as to maintain the output current at the desired level. The auxiliary power supply and reference voltage circuits provide all d-c power requisite for the operation of the regulatory circuits.

2.2 CIRCUIT DESCRIPTION

2.2.1 A-C Input Circuit. The a-c input circuit includes power ON switch S1 and indicator lamp DS1, fuse F1, and transformer T1. Transformer T1 provides a-c inputs to both the main power supply and the auxiliary power supply circuits.

2.2.2 Main Power Supply Circuit. The main power supply circuit includes one secondary winding of transformer T1, full wave bridge rectifier CR1, filter capacitor C1, and the parallel-connected series regulator transistors. The output voltage of the power supply is controlled directly by the series regulator circuit. An increase in the effective resistance of the regulator circuit increases the voltage drop across the regulator and thereby reduces the power supply output voltage. Similarly, a decrease in the effective resistance of the regulator circuit results in an increase of the power supply output voltage. When the power supply is operating in the constant voltage mode, the voltage drop across the series regulator is governed by the voltage error amplifier, which monitors the power supply output voltage. During the constant current mode of operation, the voltage drop across the series regulator is controlled by the current error amplifier, which monitors the power supply output current. The voltage error amplifier adjusts the voltage drop across the series regulator to compensate directly for power supply output voltage variations. The current error amplifier compensates for any tendency of the output current to rise by increasing the voltage drop across the series regulator sufficiently to constrain the power supply output current to the pre-selected level.

2.2.3 Voltage Error Amplifier. The voltage error amplifier compares the output voltage of the power supply with a reference voltage established by the setting of the dual-concentric fine and coarse output voltage control potentiometer (R3A/R3B) and produces an output that effectively is opposite in magnitude and direction to the undesired variation of the power supply output voltage. This output is applied to the series regulator circuit, where it adjusts the series regulator voltage drop in a direction necessary to nullify the change in power supply output voltage.

2.2.4 Current Error Amplifier. The current error amplifier compares the voltage drop produced by power supply output current flow through series resistor R2 with a reference voltage established by the setting of maximum output current control potentiometer R4. An increase in output current

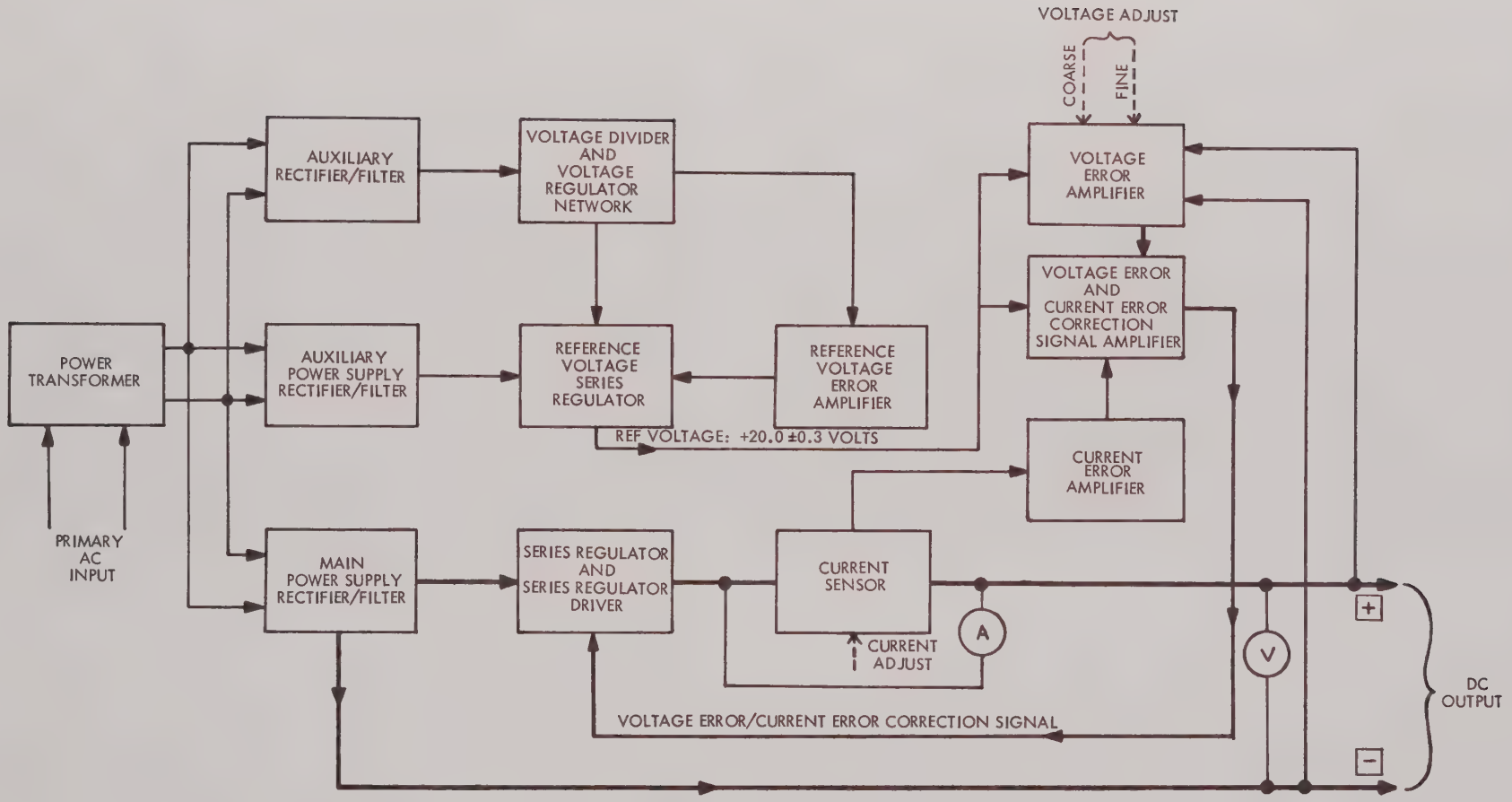


Figure 2-1. Basic Circuits of QS Series DC Power Supplies

demand as evidenced by increased voltage drop across the series resistor causes the current error amplifier to increase the voltage drop across the power supply series regulator and thereby reduces the output voltage to a level insufficient to maintain the increased current flow. Similarly, a tendency toward reduced current flow causes the current error amplifier to reduce the voltage drop across the power supply series regulator and thus provide sufficient output voltage to produce the pre-established maximum current flow.

2.2.5 "OR" Gate. The output circuits of the voltage error amplifier and the current error amplifier are connected, respectively, to diodes CR109 and CR112, which form an "or" gate in the input circuit of the small signal driver stage. Diode CR109 is so biased as to be normally conducting during constant voltage operation of the power supply, and the voltage error amplifier output is therefore passed by the "or" gate, amplified by the small signal driver, and applied to the series regulator circuit. Diode CR112 is back-biased to cutoff; therefore, during the constant voltage mode of power supply operation, the output of the current error amplifier is blocked from the small signal driver input circuit.

2.2.6 As the power supply load current increases to the pre-set maximum value, the output voltage of the current error amplifier increases until the potential applied to CR112 overcomes the back bias and CR112 conducts. At this time, the power supply has entered the constant current mode of operation, diode CR109 is cut off, and the voltage error amplifier input to the small signal driver is replaced by the input from the current error amplifier.

2.2.7 Small Signal and Series Regulator Drivers. The small signal driver and series regulator driver stages serve to increase the amplitude of the corrective signal output of the associated error amplifier to a level suitable for driving the series regulator stage. Small signal driver and series regulator driver stages Q108 and Q101 are direct-coupled in a standard emitter follower configuration, and the output at the emitter of Q101 is applied to the bases of the series regulator transistors.

2.2.8 Auxiliary Power Supply Circuits. The auxiliary power supply circuits provide stable d-c operating voltages to all regulatory circuits of the main power supply. The auxiliary power supply circuits include the second secondary winding of transformer T1, a full wave bridge rectifier, a conventional series regulator/voltage error amplifier type electronic voltage regulator, a full wave rectifier/filter circuit, and associated circuit components. D-c operating voltages for the electronic voltage regulator circuit are provided by the full wave rectifier/filter circuit. Zener diodes are employed to establish stable d-c reference potentials for application to the differential voltage error amplifiers of both the auxiliary power supply and the main power supply regulatory circuits.

SECTION 3

INSTALLATION AND OPERATION

3.1 GENERAL

3.1.1 This section provides instructions concerning installation and operation of the QS series DC power supplies (see Figures 3-1, 3-2, and 4-1). Instructions provided include those for connection to the primary a-c power source, connections to the power supply output, and connections for various modes of operation. In addition, adjustment data and normal operating procedures, as required, are included.

3.2 PRIMARY AC INPUT POWER CONNECTIONS

3.2.1 To connect the power supply to the primary a-c power source, connect the a-c input to terminals 1 and 2 of terminal board TB1. If desired, the a-c circuit can be grounded by means of a connection to terminal 9 of TB1.

CAUTION

Before energizing the power supply, determine the type of operation desired and verify that the -RS and +RS remote sensing terminals of TB1 are connected either to the power supply load or the -OUT and +OUT terminals of TB1, respectively. OPERATION OF THE POWER SUPPLY WITH EITHER OF THE REMOTE SENSING TERMINALS DISCONNECTED CAN CAUSE AN OVERVOLTAGE CONDITION.

3.3 POWER SUPPLY OUTPUT CONNECTIONS

NOTE

Power supply output connections are diagrammed on the rear panel decal. See Figure 3-2.

3.3.1 Connect the power supply load to either the "+" and "-" output binding posts on the front panel of the unit or to -OUT and +OUT terminals of TB1, making certain to observe proper polarities. Either output terminal of the power supply may be grounded at the front panel by connecting a jumper between the desired output binding post and the ground binding post, or at the rear panel by connecting TB1-10 or TB1-8 to TB1-9.

3.4 REMOTE SENSING CIRCUIT CONNECTIONS

3.4.1 To use the remote sensing feature, on terminal board TB1 remove the jumpers connecting the -RS to the -OUT terminals, the +RS to the +OUT terminals and connect the +RS and -RS terminals directly to the power supply load. Be certain to observe proper polarity. If the power supply has been connected for remote voltage programming (refer to paragraph 3.5.1), DO NOT remove the existing connections to terminals -RS and -OUT of TB1; simply make the appropriate connections described above to these terminals.

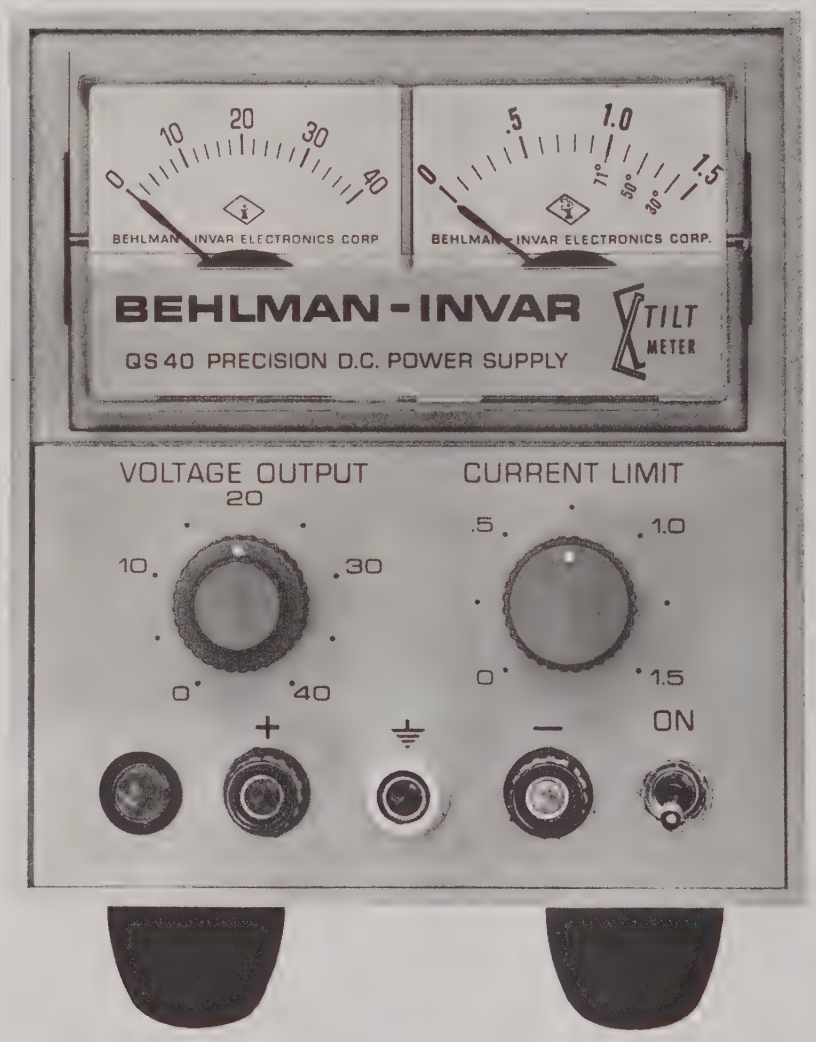


Figure 3-1. Model QS 40 DC Power Supply, Front Panel

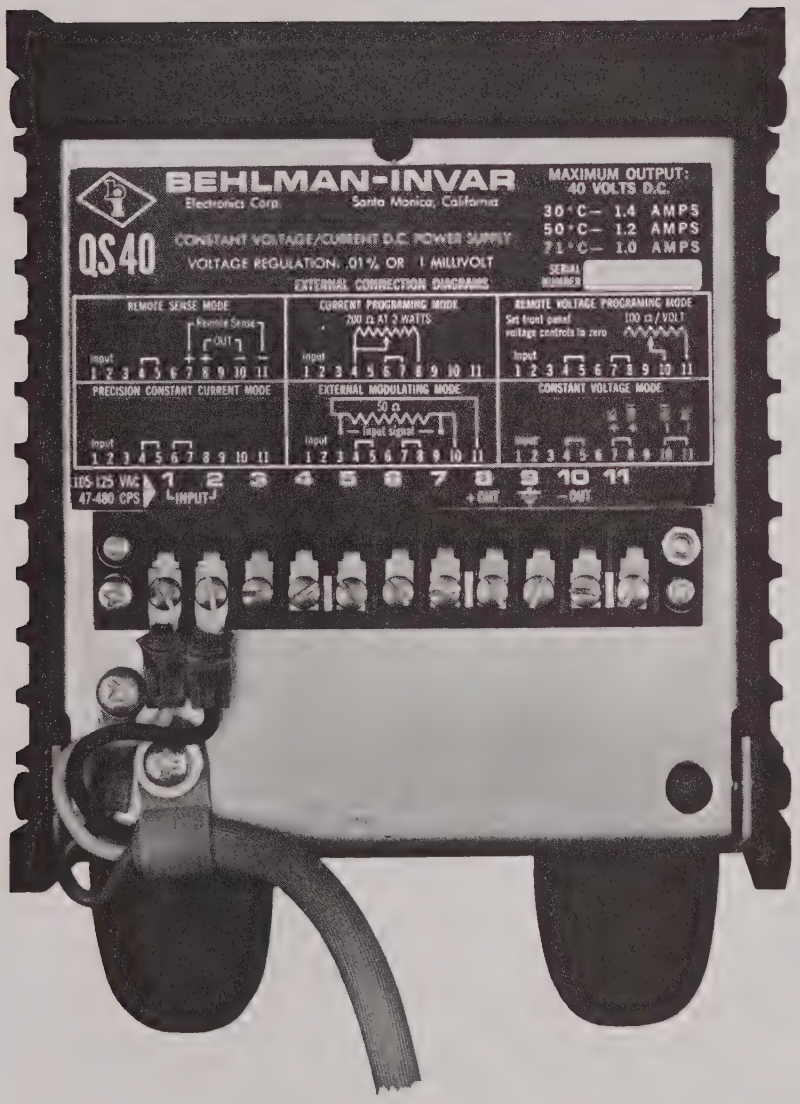


Figure 3-2. Model QS 40 DC Power Supply, Rear Panel

3.5 REMOTE VOLTAGE PROGRAMMING CONNECTIONS AND ADJUSTMENTS

3.5.1 Remote voltage programming connections are accomplished by removing the jumper connecting the -RS and -OUT terminals of terminal board TB1 and then connecting a 100 ohms per volt remote programming resistor or a 1 volt per volt remote programming voltage between the -RS and -OUT terminals as indicated on the schematic diagram, Figure 4-1. To make the remote voltage programming circuit operative, it is necessary to rotate both the fine and coarse output voltage controls to the fully counterclockwise positions. (This adjustment effectively removes these controls from the output voltage control circuit, thereby investing control of the power supply output voltage in the external variable resistance.) Note that the remote sensing connections described in paragraph 3.4.1 remain the same, when remote output voltage programming is employed.

3.6 REMOTE CURRENT PROGRAMMING CONNECTIONS

3.6.1 Remote current programming is accomplished by removing the jumpers connecting terminals 4 and 5 of TB1 and connecting a 200-ohm remote programming resistor between terminals 4 and 8 of TB1.

3.7 EXTERNAL MODULATION CONNECTIONS

3.7.1 External modulation of the power supply output voltage is effected by removing the jumper connecting -OUT terminal 10 of TB1 to -RS terminal 11 of TB1 and replacing it with a 50-ohm, 1/2-watt composition resistor. The modulating signal input is then connected across terminals 10 and 11 of TB1.

3.8 PRECISION CONSTANT CURRENT CONNECTION

3.8.1 Remove jumpers 10-11 and 7-8 and add jumper from 6 to 7 of TB1. In this configuration, the power supply is in the constant current mode of operation only, and the voltmeter and voltage controls are inoperative.

3.9 CONTROLS AND INDICATORS

3.9.1 The Model QS series power supply front panel controls and indicators, and the functions thereof, are as follows:

Tilt-Meter®	Adjusts for most convenient viewing by pushing on top or bottom of meter cover.
Power ON switch	Applies primary a-c power to the power supply.
Power indicator lamp	Lights to indicate that primary a-c power is applied to the power supply.
VOLTAGE OUTPUT	A dual concentric control enabling power supply output to be varied through the rated voltage range. Outer knob provides a coarse adjustment and the inner knob provides a fine adjustment.
CURRENT LIMIT control	Enables selection of maximum output current at any point in the rated output current range of the power supply.

VOLTAGE OUTPUT meter	Monitors power supply output voltage.
CURRENT LIMIT meter	Monitors power supply output current.

3.10 OPERATING PROCEDURES

3.10.1 To operate the power supply, proceed as follows:

a. Check that the intended load is properly connected to the front panel binding posts or to terminals 8 and 10 of terminal board TB1.

b. Check that, where necessary, the positive or negative output circuit of the power supply is grounded to the front panel binding post or to terminal 9 of TB1.

c. Check that the following connections (where used) have been completed correctly.

(1) Remote sensing (refer to paragraph 3.4.1).

(2) Remote voltage programming (refer to paragraph 3.5.1).

(3) Remote current programming (refer to paragraph 3.6.1).

(4) Precision constant current (refer to paragraph 3.8.1).

d. Place the OUTPUT VOLTAGE and CURRENT LIMIT controls in the "0" positions.

e. Place the power switch in the ON position and note that power indicator lamp lights.

f. Adjust the OUTPUT VOLTAGE and CURRENT LIMIT controls to produce the required power supply output voltage and the maximum output current. Refer to OUTPUT VOLTAGE and CURRENT LIMIT meters to verify power supply output characteristics.

3.11 EXTERNAL MODULATION OF POWER SUPPLY OUTPUT VOLTAGE

3.11.1 Noise signals or other signals may be injected into the power supply output voltage by means of the connections described in paragraph 3.7.1, above. These signals are fed directly into the voltage error differential amplifier circuit, where they exert an effect similar to that of the normal corrective error feedback signals. Normal power supply regulation is maintained; the effect of the 50-ohm resistance in the positive remote sensing circuit is merely to offset the power supply output voltage by approximately 0.5 volt.

3.11.2 The amplitude of the external modulating signal input will, in large part, be determined both by the waveform and the frequency of the modulating signal (see Figure 3-3). To insure against distortion arising from possible overdriving of the voltage error amplifier circuit the modulation signal level should be set initially at 2 or 3 millivolts peak-to-peak and the power supply output should be monitored by means of an oscilloscope; the modulating signal level then being adjusted as required to produce an undistorted power supply output.

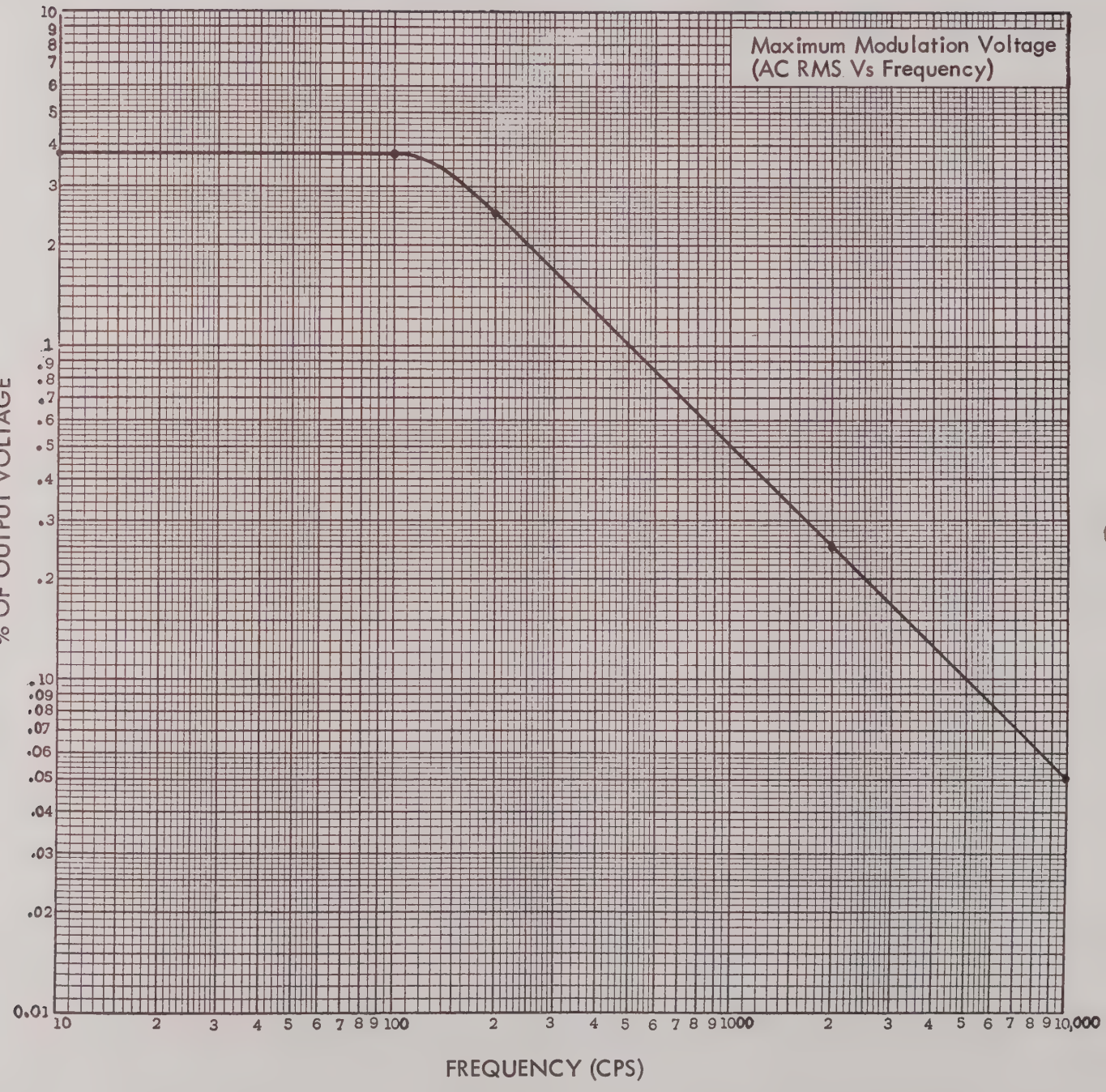


Figure 3-3. QS Series External Modulation Characteristic

SECTION 4

MAINTENANCE

4.1 GENERAL

4.1.1 This section contains both general preventive maintenance procedures and general corrective maintenance procedures for the Behlman-Invar QS series DC power supplies. Conservative circuit design and liberal derating of components have resulted in the development of a power supply requiring a minimum of maintenance. Circuit stability is such that no internal adjustments are normally required nor recommended.

4.2 CLEANING

4.2.1 Remove dust, dirt, and other foreign material using a small brush and vacuum cleaner. Low pressure air may be used if a vacuum cleaner is not available. When using the air, be sure to aim the air stream so that the foreign material will be blown away from the unit being cleaned, rather than into recesses, slots, etc. Use a cloth and a suitable solvent to remove material not removable by means of the above procedure.

4.3 TROUBLESHOOTING

4.3.1 Troubleshooting techniques normally used with transistorized equipment are appropriate for the power supply. Prior to initiating detailed troubleshooting procedures in those cases where the power supply is operative, but not functioning properly, check the output connection, the local sensing jumpers, or when used, the remote sensing connections, for security. Imperfect connections at any of these points can seriously impair the voltage regulating function. Refer to the block diagram, Figure 2-1, and the schematic diagram, Figure 4-1, as aids to troubleshooting.

4.3.2 Checking Transistors. Check transistors with an instrument that has current limiting capability. Observe proper polarity for PNP or NPN type transistors to avoid error in measurement. The forward transistor resistance is low but never zero; backward resistance is always higher than the forward resistance. Resistance between transistor collector and emitter, in either direction, varies with temperature; the variation being greater for the forward direction resistance. For good transistors, the forward resistance for any junction is always greater than zero.

4.3.3 Checking Capacitors. The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In all cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

4.4 REPAIR AND REPLACEMENT

4.4.1 Do not assume trouble is necessarily isolated when only one part is determined initially to be defective. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning the power on, before checking for additional defective components could damage the replacement transistor.

4.4.2 When reconnecting or replacing electrical parts, observe the usual standards of good practice, paying particular attention to the following points:

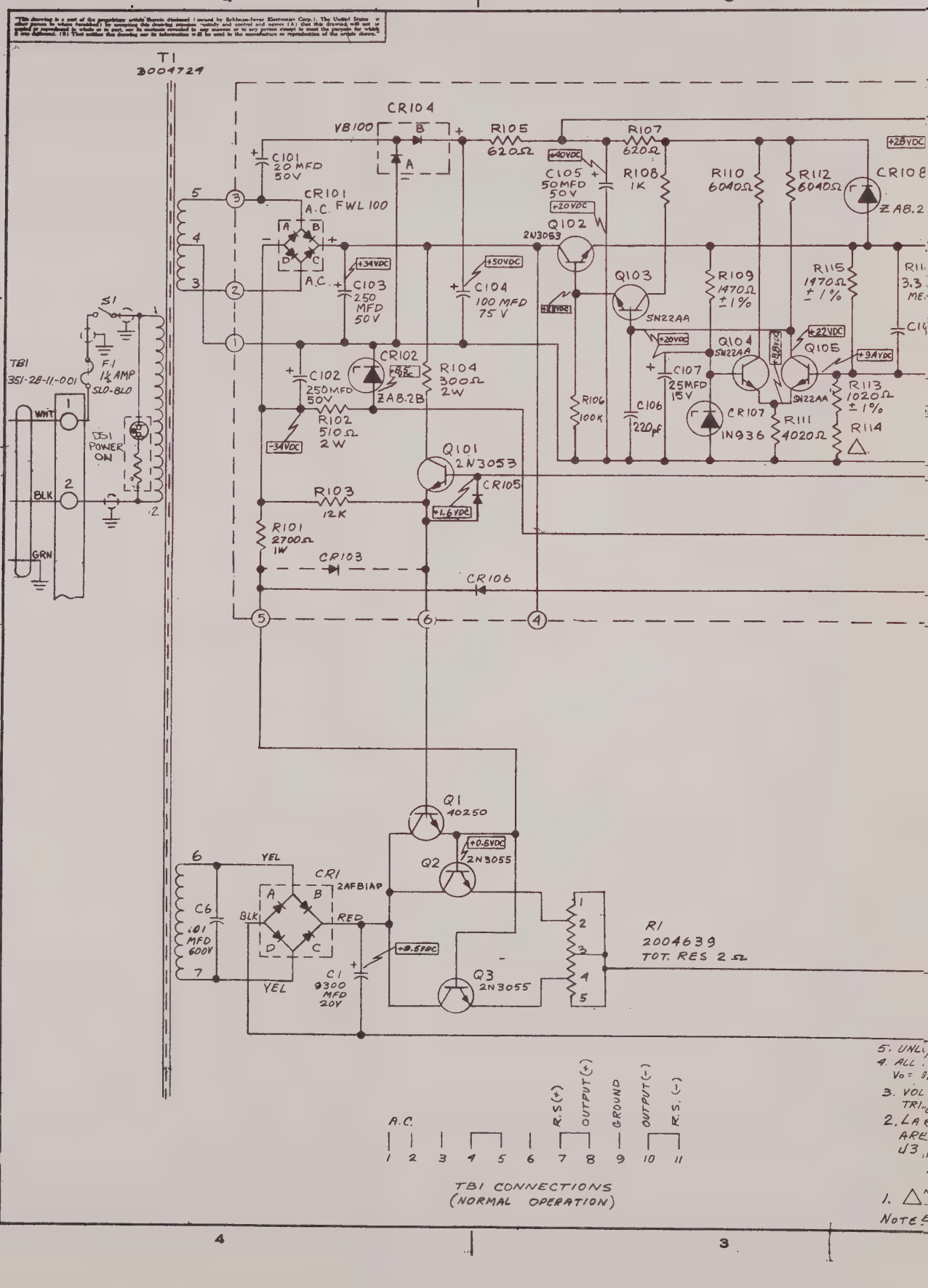
a. Use exact equivalent parts.

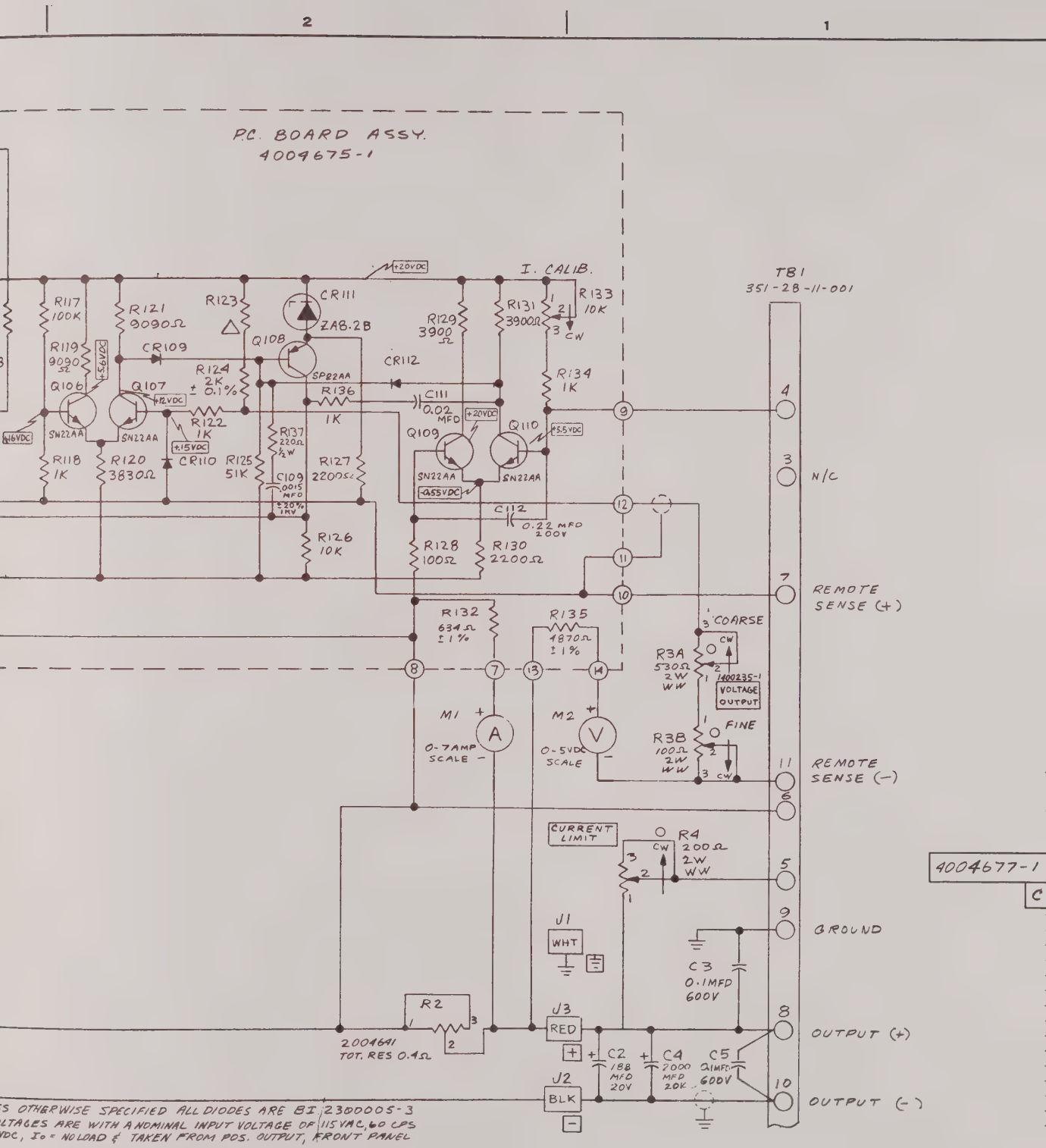
b. Place parts and wiring in same locations as before repair.

c. Take care to avoid damage, particularly burning insulation, scratching or breaking printed circuits, or pinching wires.

d. When replacing parts on printed circuit boards, do not attempt to unsolder them. Clip the leads to the part to be removed, and solder the new part to the portions of the leads which remain connected to the board.

e. When soldering semiconductor devices, hold the lead being soldered with a pair of pliers placed between the component and the solder joint to provide an effective heat sink.

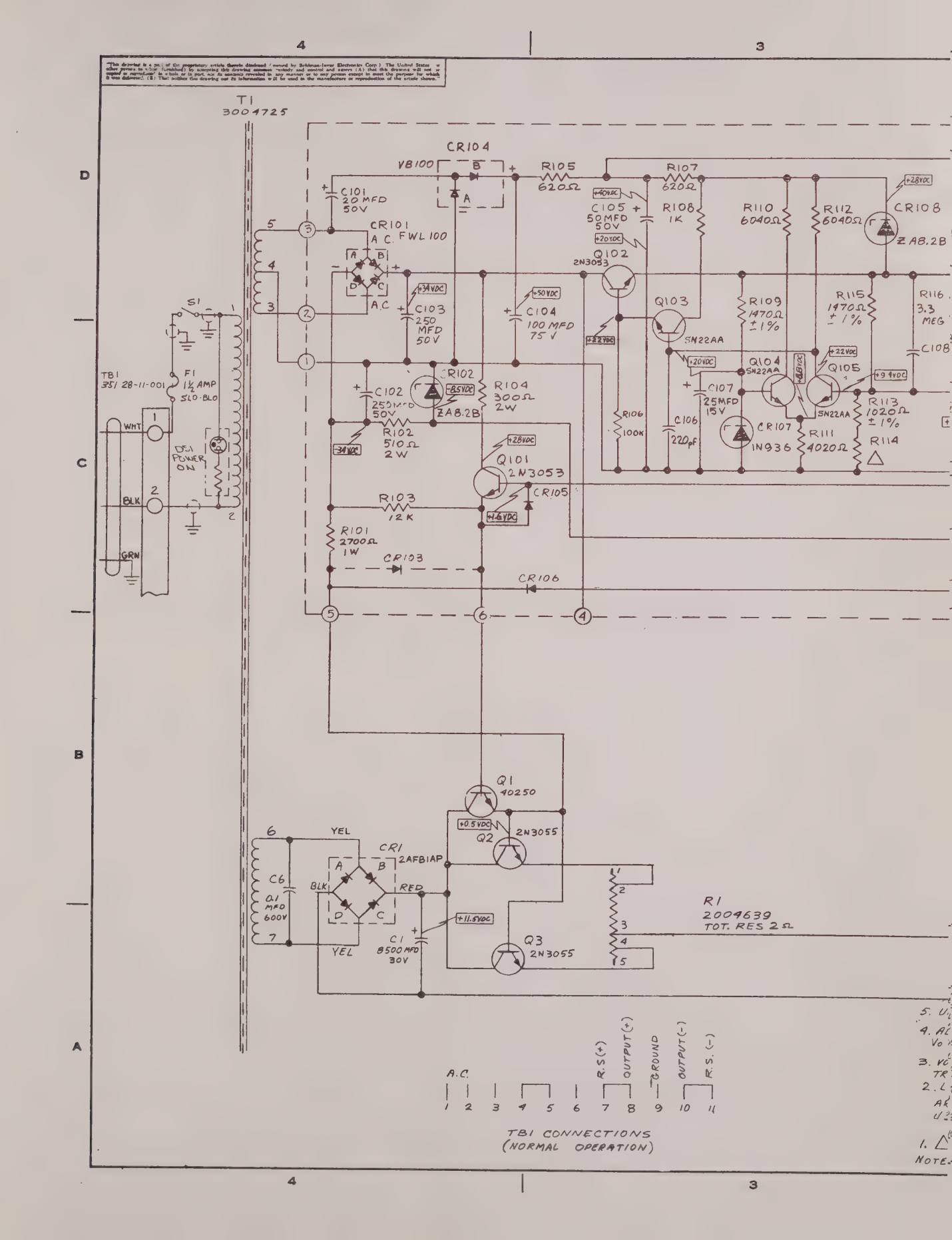

T1
3004729
CR104
VB100
R105
620Ω
R107
620Ω
+28VDC
C101
20 MFD
50V
CR101
A.C. FWL 100
C105
50MFD
50V
R108
1K
R110
6040Ω
R112
6040Ω
CR108
Z AB.2
+40VDC
+20VDC
Q102
2N3053
+34VDC
C103
250
MFD
50V
+50VDC
C104
100 MFD
75 V
Q103
SN22AA
R109
1470Ω
±1%
R115
1470Ω
±1%
+22VDC
+9.4VDC
Q104
SN22AA
Q105
SN22AA
C107
25MFD
15V
CR107
IN936
R111
4020Ω
R113
1020Ω
±1%
R114
C106
220pf
R106
100K
CR102
Z AB.2B
R104
300Ω
2W
C102
250MFD
50V
R102
510Ω
2W
-34VDC
Q101
2N3053
CR105
+1.6VDC
R103
12K
R101
2700Ω
1W
CR103
CR106
S1
F1
1½ AMP
SLO-BLO
TB1
351-28-11-001
WHT
BLK
GRN
DS1
POWER
ON
Q1
40250
Q2
2N3055
+0.6VDC
CR1
2AFB1AP
C6
.01
MFD
600V
YEL
BLK
RED
C1
9300
MFD
20V
+8.5VDC
Q3
2N3055
R1
2004639
TOT. RES 2Ω
A.C.
R.S.(+)
OUTPUT(+)
GROUND
OUTPUT(-)
R.S.(-)
1 2 3 4 5 6 7 8 9 10 11
TB1 CONNECTIONS
(NORMAL OPERATION)



S OTHERWISE SPECIFIED ALL DIODES ARE BI 2300005-3
LTAGES ARE WITH A NOMINAL INPUT VOLTAGE OF 115VAC, 60 CPS
VDC, Io = NO LOAD & TAKEN FROM POS. OUTPUT, FRONT PANEL
AGE MEASUREMENTS TAKEN WITH A
ET MODEL 630 HA.
T REF DESIGNATIONS USED
C111, CR112, Q110, R137, C6,
Q3, M2, R4, T1, TB1.

DENOTES SELECT IN TEST

Figure 4-1A. QS 5 DC Power Supply, Schematic Diagram


T1
3004725
CR104
VB100
R105
620Ω
R107
620Ω
C101
20 MFD
50V
CR101
A.C. FWL 100
C105
50MFD
50V
R108
1K
R110
6040Ω
R112
6040Ω
CR108
Z A8.2B
Q102
2N3053
Q103
SN22AA
R109
1470Ω
±1%
R115
1470Ω
±1%
R116
3.3
MEG
C108
C103
250
MFD
50V
C104
100 MFD
75 V
S1
TB1
335 28-11-001
F1
1½ AMP
SLO-BLO
WHT
BLK
GRN
DS1
POWER
ON
CR102
Z A8.2B
C102
250MFD
50V
R104
300Ω
2W
R102
510Ω
2W
R106
100K
C106
220pF
C107
25MFD
15V
CR107
IN936
Q104
SN22AA
Q105
SN22AA
R111
4020Ω
R113
1020Ω
±1%
R114
Q101
2N3053
CR105
R103
12K
R101
2700Ω
1W
CR103
CR106
Q1
40250
Q2
2N3055
Q3
2N3055
CR1
2AFB1AP
C6
.01
MFD
600V
C1
8500 MFD
30V
R1
2009639
TOT. RES 2Ω
+34VDC
-34VDC
+50VDC
+40VDC
+20VDC
+22VDC
-85VDC
+28VDC
+20VDC
+22VDC
-48VDC
+9.9VDC
+1.6VDC
+0.5VDC
+11.5VDC
YEL
BLK
RED
YEL
A.C.
R.S.(+)
OUTPUT(+)
GROUND
OUTPUT(-)
R.S.(-)
1 2 3 4 5 6 7 8 9 10 11
TB1 CONNECTIONS
(NORMAL OPERATION)

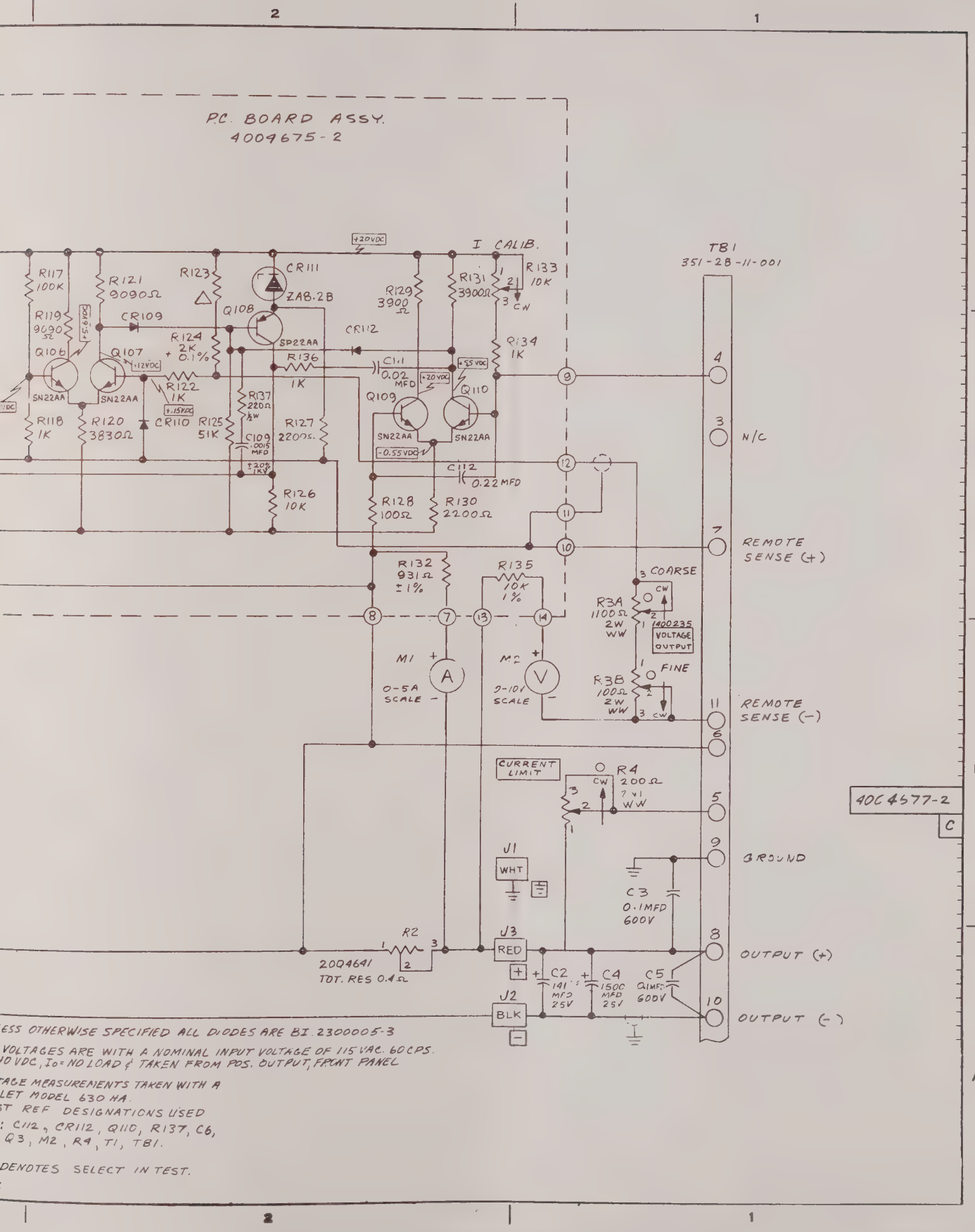
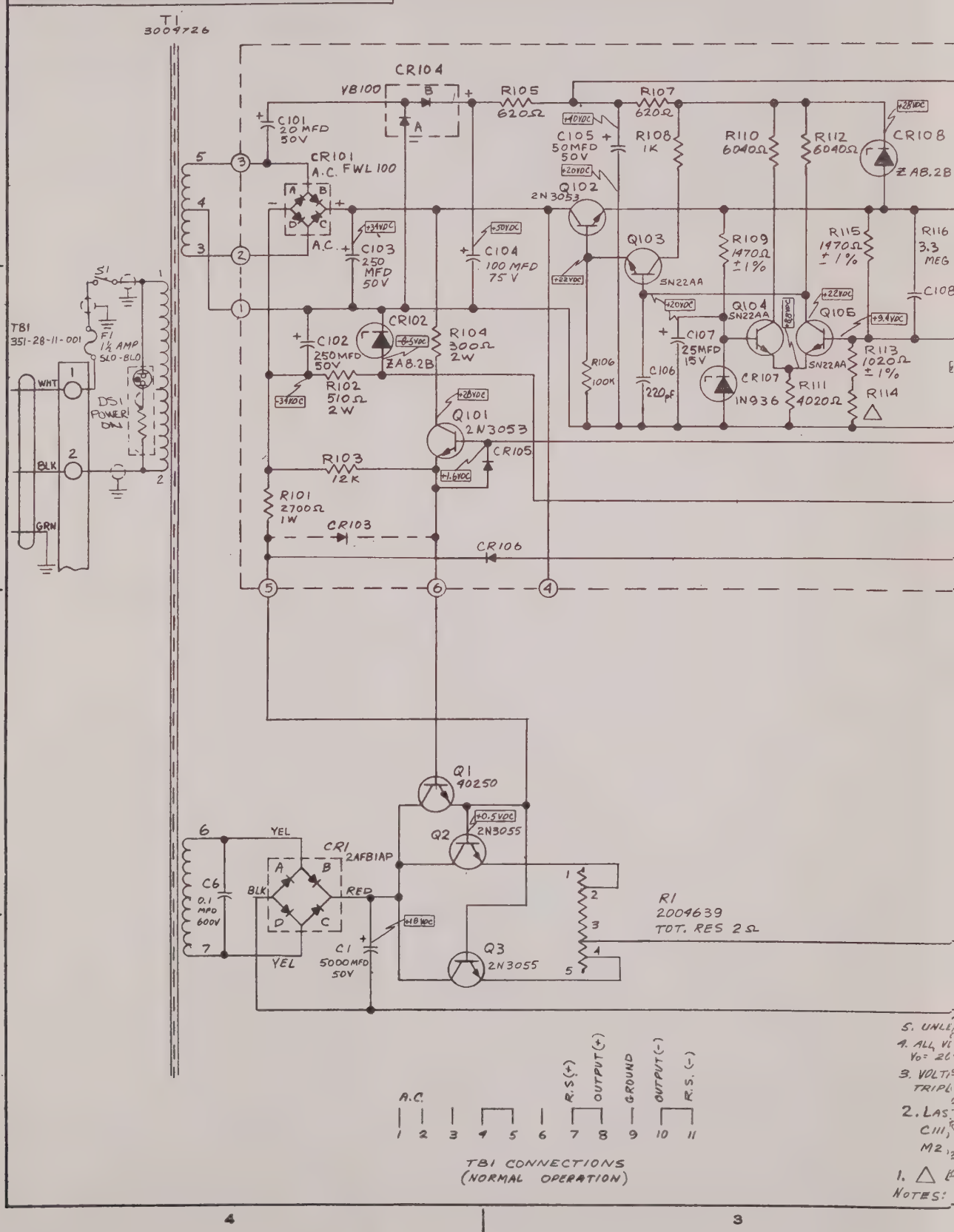


Figure 4-1B. QS 10 DC Power Supply, Schematic Diagram

This drawing is a part of the proprietary subject thereto disclosed / owned by Schlumberger-Inversy Electronics Corp.). The United States or other parties to whom furnished by accepting this drawing assumes custody and control and agrees (A) that this drawing will not be copied or reproduced in whole or in part, nor its contents revealed in any manner or to any person except to meet the purpose for which it was delivered. (B) That neither the drawing nor its information will be used in the manufacture or reproduction of the article shown.



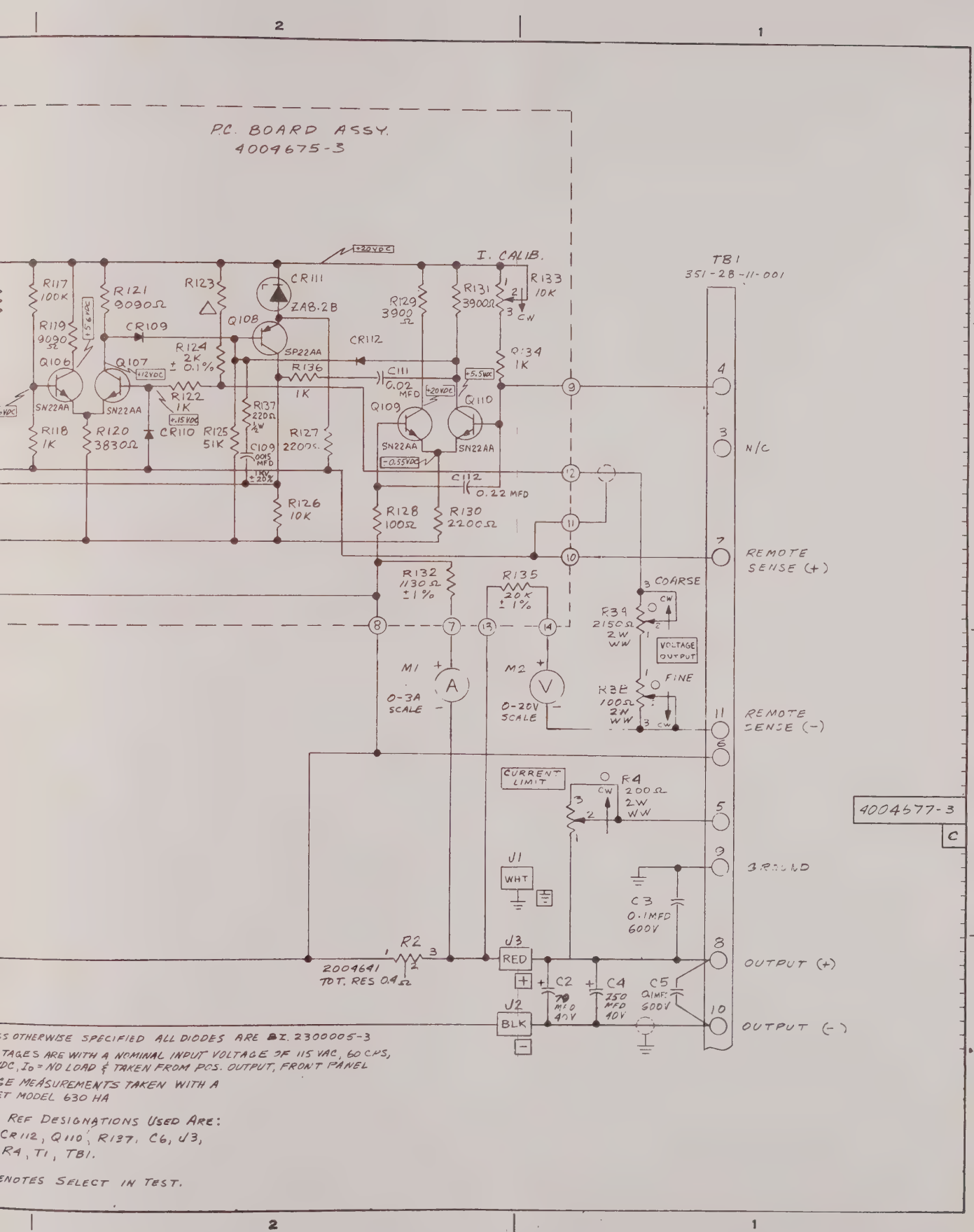


Figure 4-1C. QS 20 DC Power Supply, Schematic Diagram

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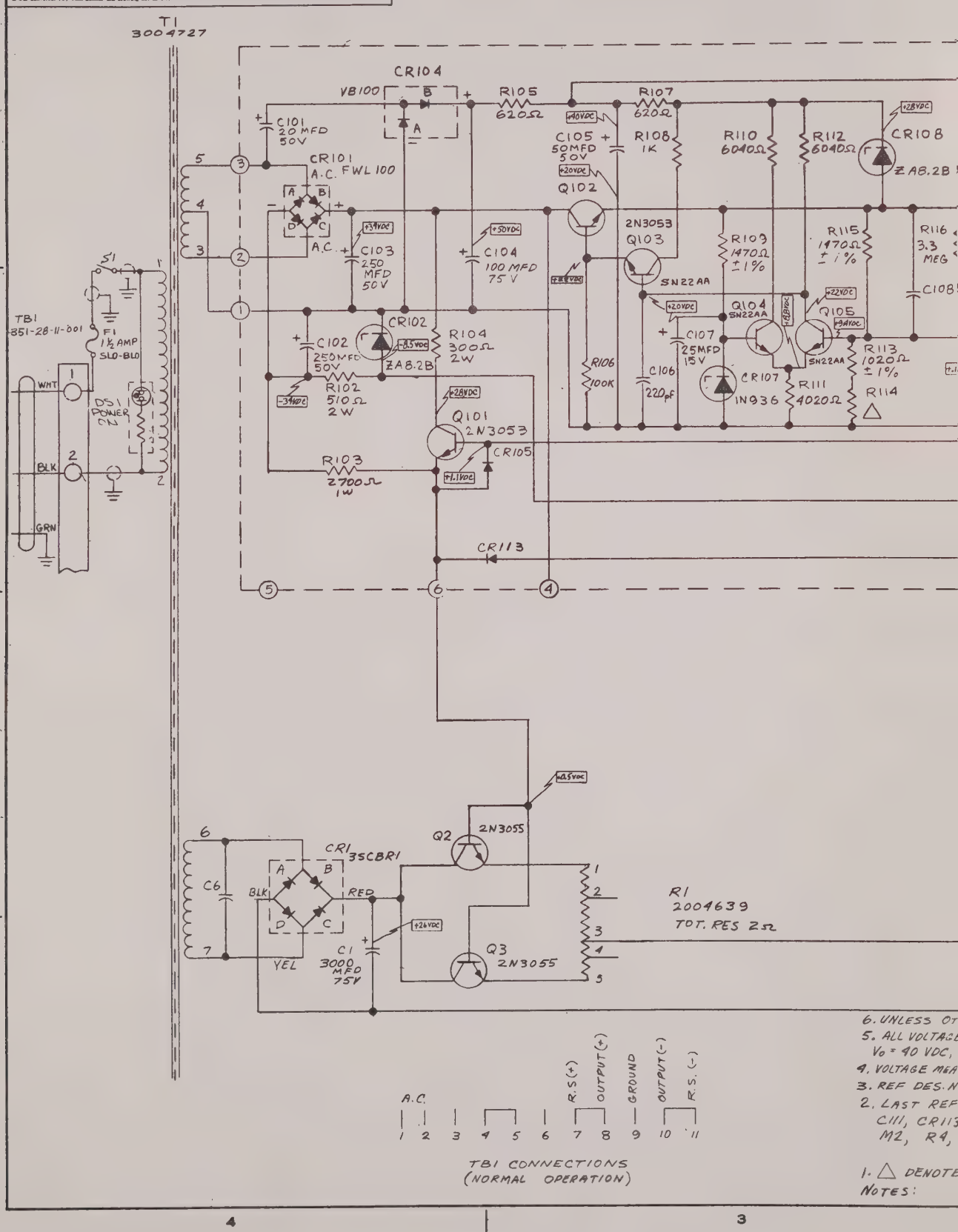

6. UNLESS OT
5. ALL VOLTAGE
V_o = 40 VDC,
4. VOLTAGE MEA
3. REF DES. N
2. LAST REF
C111, CR113
M2, R4,
1. △ DENOTE
NOTES:

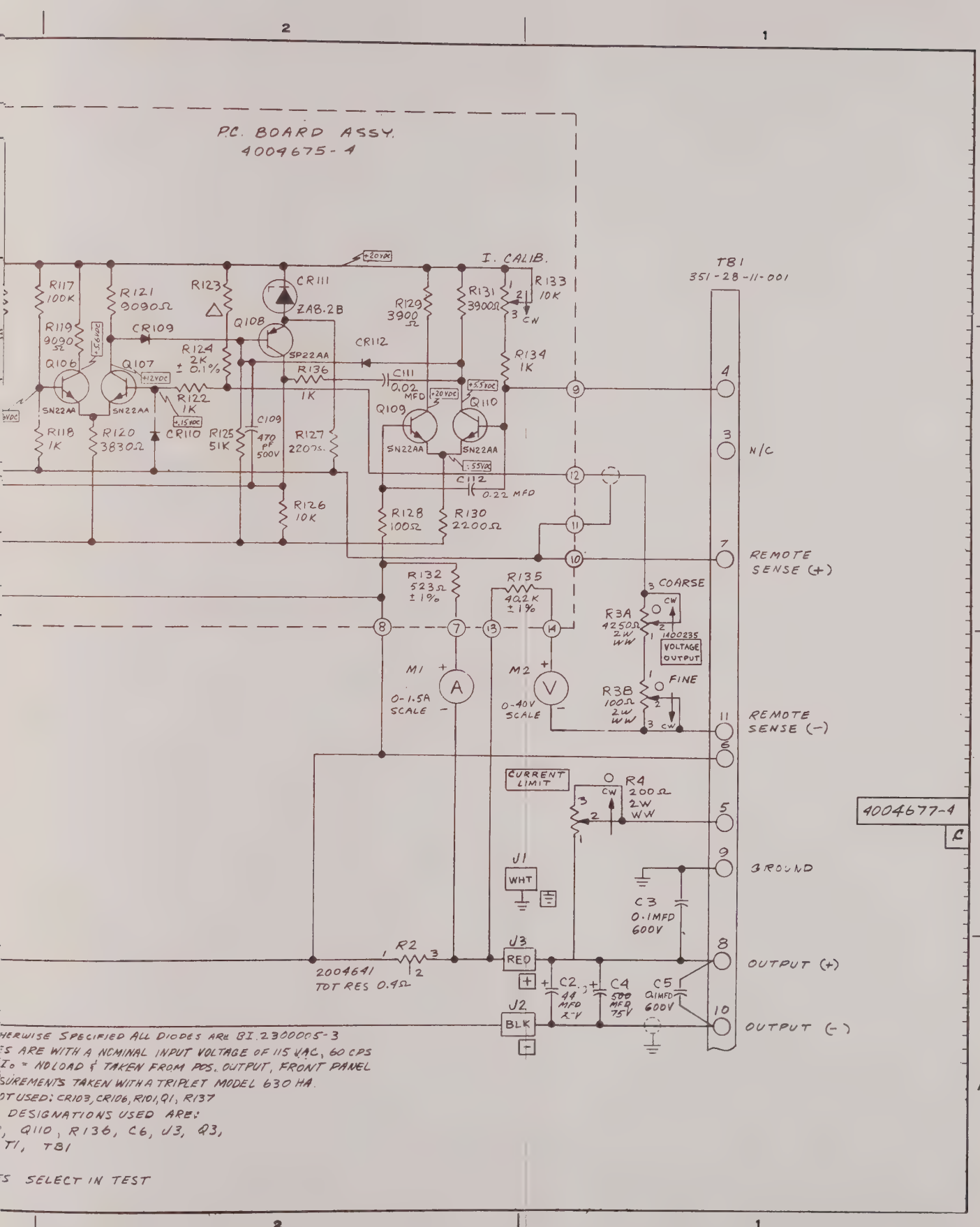

Figure 4-1D. QS 40 DC Power Supply, Schematic Diagram

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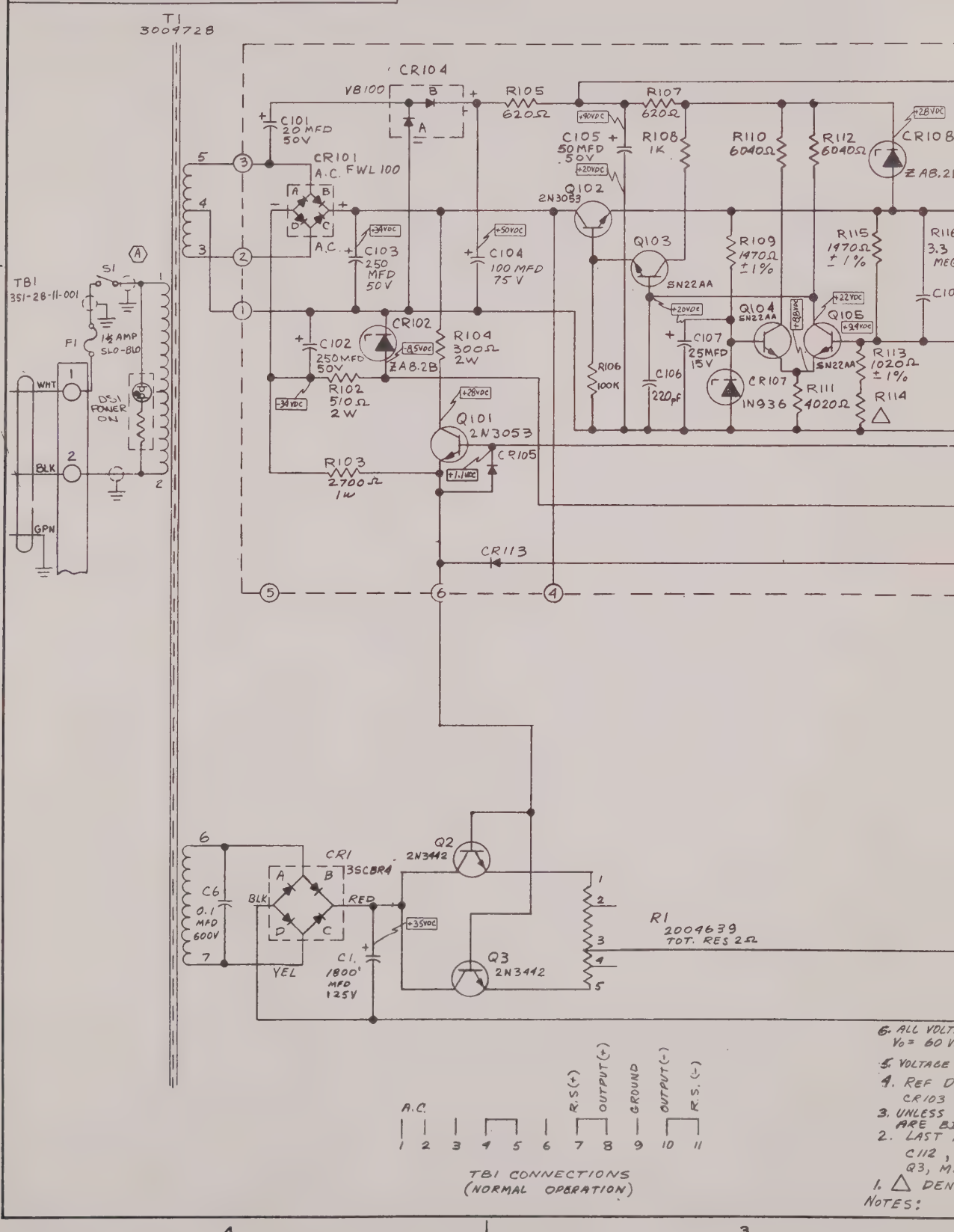


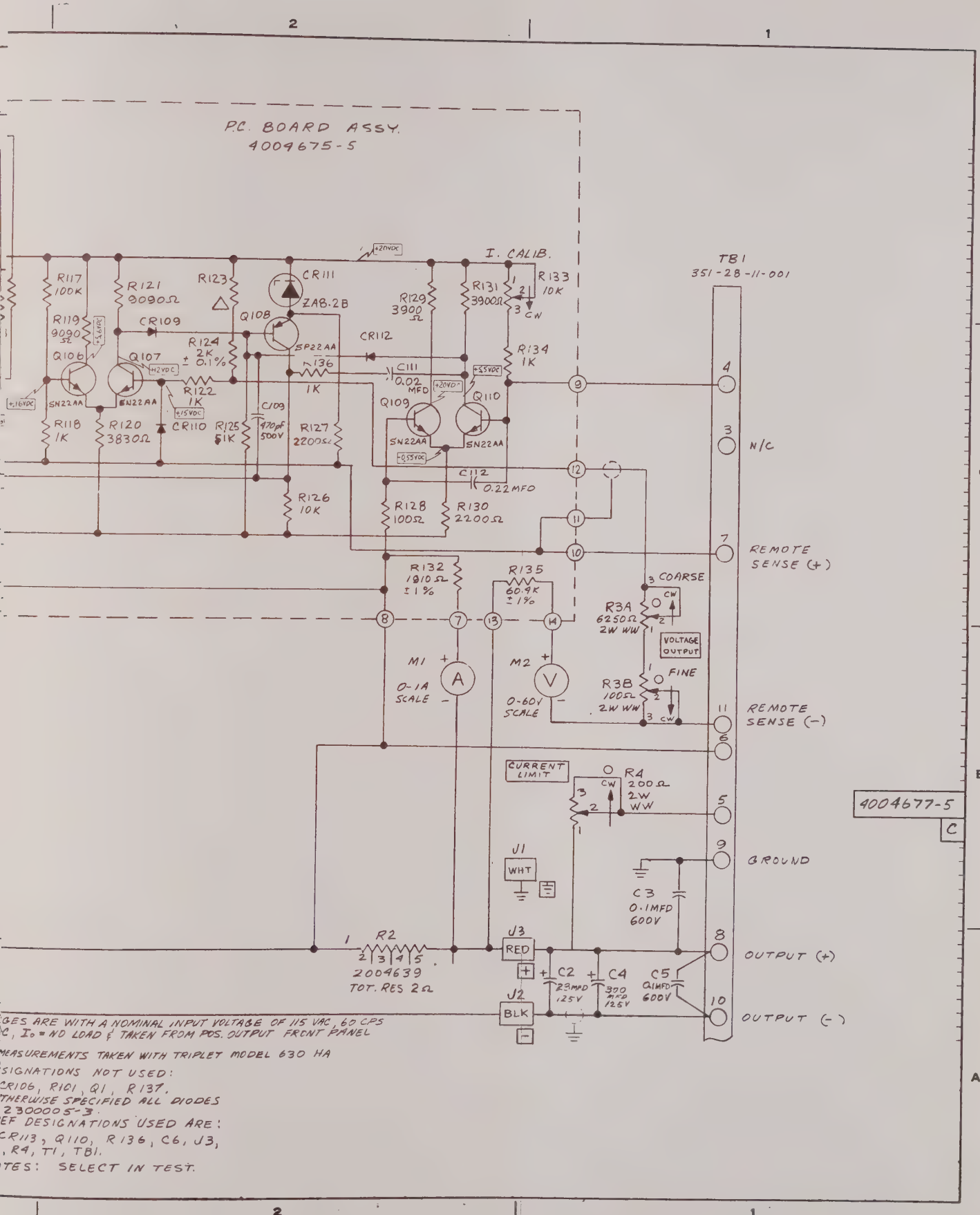
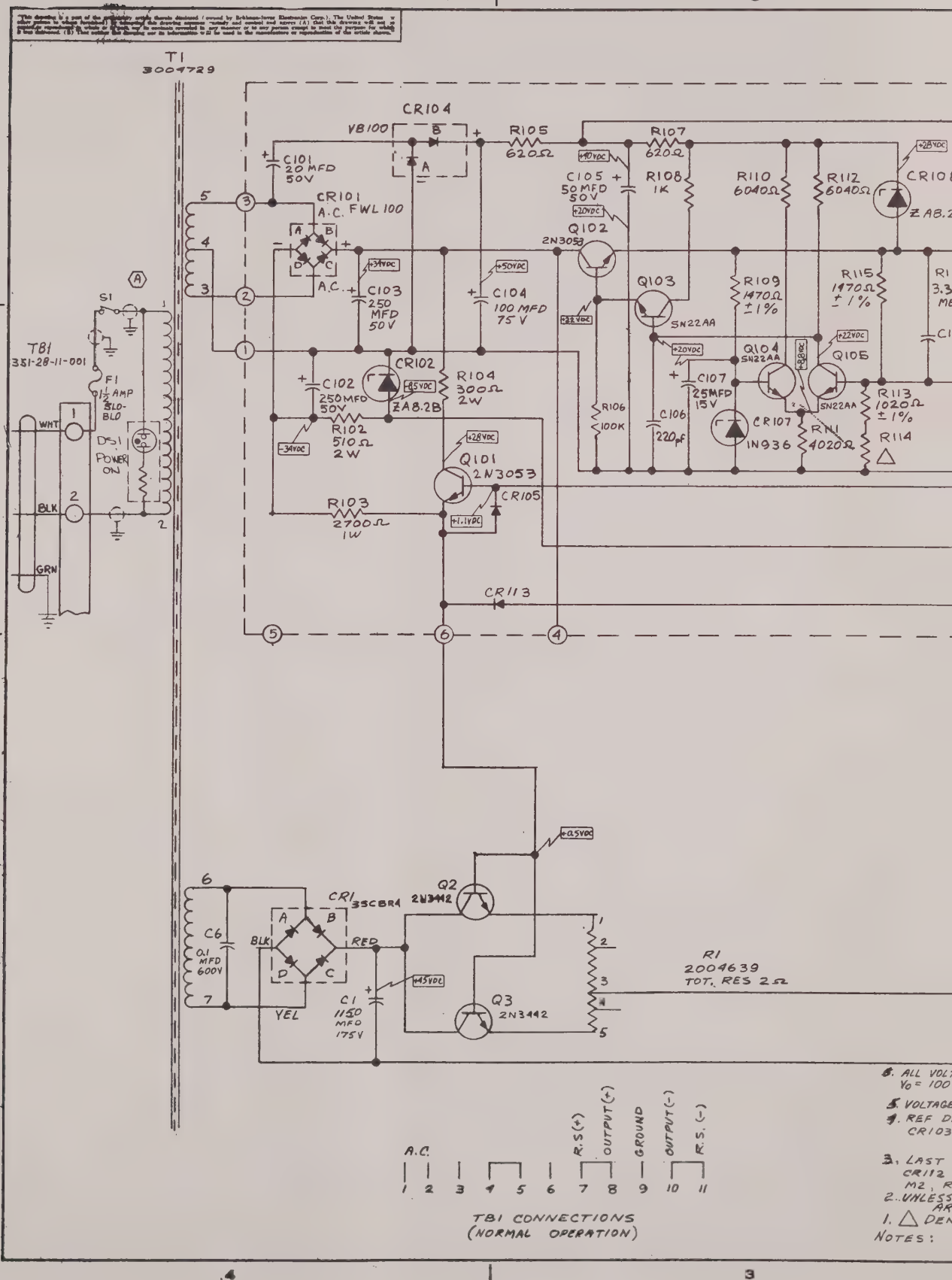
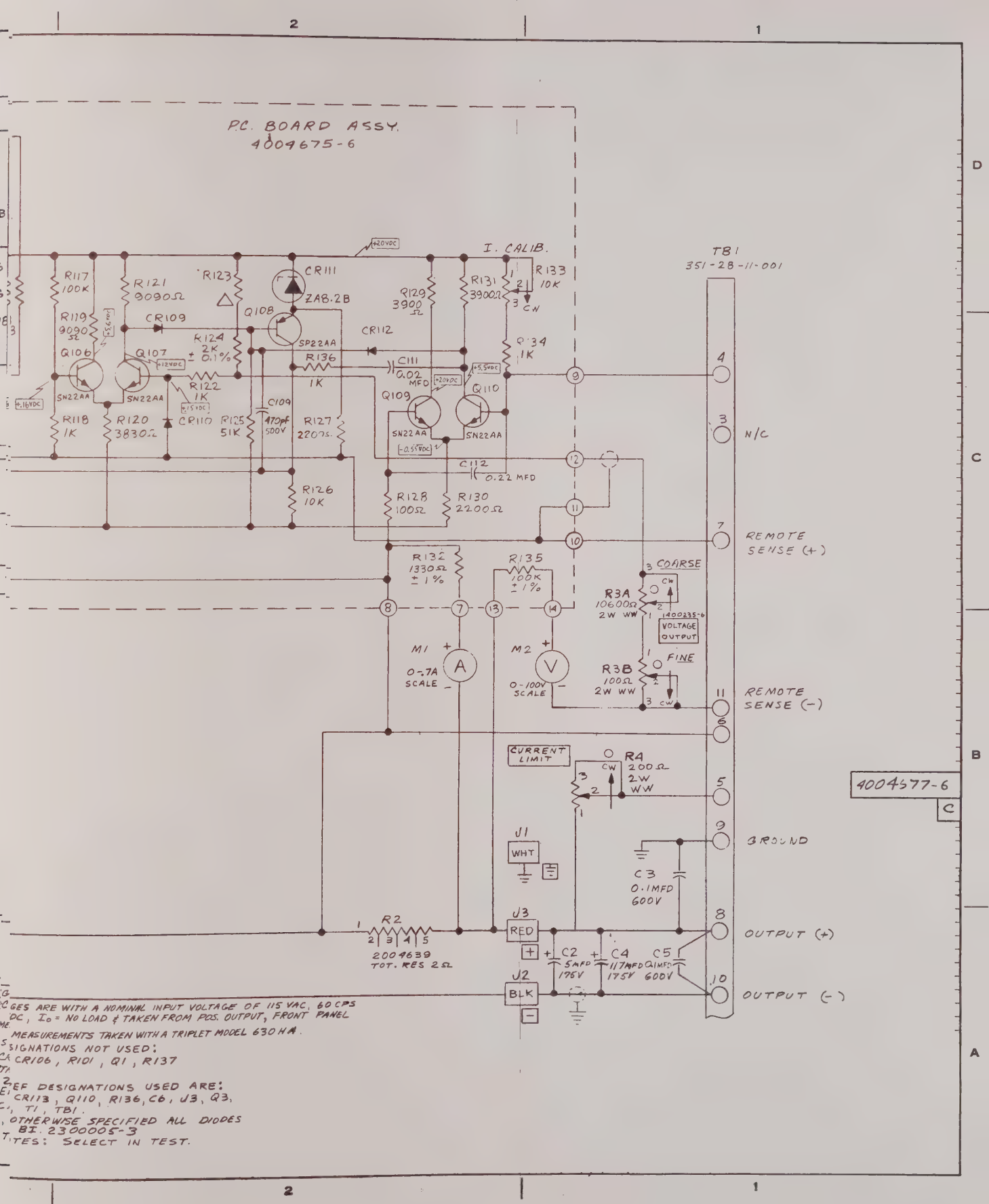


Figure 4-1E. QS 60 DC Power Supply, Schematic Diagram


T1
3004729
CR104
VB100
C101
20 MFD
50V
R105
620Ω
R107
620Ω
+28VDC
C105
50 MFD
50V
R108
1K
R110
6040Ω
R112
6040Ω
CR101
A.C. FWL 100
Q102
2N3053
Q103
SN22AA
R109
1470Ω
±1%
R115
1470Ω
±1%
C103
250
MFD
50V
C104
100 MFD
75 V
C102
250MFD
50V
CR102
ZA8.2B
R104
300Ω
2W
R102
510Ω
2W
R106
100K
C106
220pf
C107
25MFD
15V
CR107
IN936
Q104
SN22AA
Q105
SN22AA
R113
1020Ω
±1%
R114
R111
4020Ω
Q101
2N3053
CR105
R103
2700Ω
1W
CR113
TB1
351-28-11-001
S1
F1
½ AMP
SLO-
BLO
DS1
POWER
ON
WHT
BLK
GRN
C6
0.1
MFD
600V
CR1
35CBR4
Q2
2N3442
Q3
2N3442
C1
1150
MFD
175V
RED
YEL
R1
2004639
TOT. RES 2Ω
A.C.
R.S.(+)
OUTPUT(+)
GROUND
OUTPUT(-)
R.S.(-)
1 2 3 4 5 6 7 8 9 10 11
TB1 CONNECTIONS
(NORMAL OPERATION)
NOTES:



GES ARE WITH A NOMINAL INPUT VOLTAGE OF 115 VAC, 60 CPS
DC, I_o = NO LOAD & TAKEN FROM POS. OUTPUT, FRONT PANEL
MEASUREMENTS TAKEN WITH A TRIPLET MODEL 630 HA.
SIGNATIONS NOT USED:
CR106, R101, Q1, R137
EF DESIGNATIONS USED ARE:
CR113, Q110, R136, C6, U3, Q3,
C1, T1, TB1.
OTHERWISE SPECIFIED ALL DIODES
BI. 2300005-3
TES: SELECT IN TEST.

Figure 4-1F. QS 100 DC Power Supply, Schematic Diagram

SECTION 5

PARTS LIST

5.1 INTRODUCTION

5.1.1 This section provides the information necessary for procuring replacements for all electrical parts of the QS series DC power supplies. The components tabulated in the parts list are grouped by assembly, and arranged in each assembly in alpha-numerical sequence according to reference designations.

5.2 VENDORS' CODES. Approved vendors' codes, as listed in Federal Cataloging Handbook H4-1, are used in this parts list and are listed below in numerical sequence.

CODE	VENDOR'S NAME AND ADDRESS
00656	Aerovox Corp. New Bedford, Mass.
01295	Texas Instruments, Inc. Semiconductor-Components Div. Dallas, Texas
02799	Arco Capacitors, Inc. Los Angeles, Calif.
03614	Bussmann Mfg. Div. of McGraw-Edison Co. Los Angeles, Calif.
03797	Eldema Corp. Compton, Calif.
04713	Motorola, Inc. Semiconductor Products Div. Phoenix, Arizona
04746	Behlman-Invar Electronics Corp. Santa Monica, Calif.
05820	Wakefield Engineering, Inc. Wakefield, Mass.
06124	P.R. Mallory and Co., Inc. West Coast Laboratories Lakewood, Calif.
06416	Pacific Resistor Co., Inc. Santa Monica, Calif.
07263	Fairchild Camera and Instrument Co. Semiconductor Division Mountain View, Calif.
09023	Cornell-Dubilier Electric Corp. Electrolytics and Paper Tubular Div. Sanford, North Carolina
14099	Semtech Corp. Newbury Park, Calif.
14655	Cornell-Dubilier Electric Corp. Newark, New Jersey
14752	Electro Cube, Inc. South Pasadena, Calif.
18796	Erie Technological Products Technical Materials Division State College, Pa.
58474	The Superior Electric Co. Bristol, Conn.
70903	Belden Mfg. Co. Chicago, Ill.
71450	CTS Corp. Elkhart, Ind.
71590	Centralab Division of Globe-Union Inc. Milwaukee, Wis.

CODE	VENDOR'S NAME AND ADDRESS
71785	Cinch Mfg. Co. and Howard B. Jones Division Chicago, Ill.
75915	Littelfuse, Inc. Des Plaines, Ill.
76149	Mallory Electric Corp. Detroit, Michigan
80294	Bourns Laboratories, Inc. Riverside, Calif.
81349	Military Specifications Promulgated by Standardization Div. Directorate of Logistic Services DSA
81483	International Rectifier Corp. El Segundo, Calif.
83330	Herman H. Smith, Inc. Brooklyn, New York
91662	Elco Corp. Willow Grove, Pa.
95146	Alco Electronics Mfg. Co. Lawrence, Mass.
95445	Radio Corporation of America Frequency Bureau New York, New York

5.3 PARTS LIST USAGE

5.3.1 Since the six different models of the QS series DC power supplies are combined in Table 5-1, Parts List for QS Series DC Power Supplies, the table is divided into two groups. The first group is the complete parts list for the Model QS 40 power supply; the second group consists of the "Parts Peculiar" tabulations for the Models QS 5, QS 10, QS 20, QS 60, and QS 100 power supplies. In the first group (QS 40 Parts List), those component reference designations identified by an asterisk are components which are peculiar to each different model. The parts information for these components may be found in the applicable "Parts Peculiar" tabulation. All other components listed are common to all models of the QS series.

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
		NOTE		
		Asterisk (*) in REF DES column indicates that component is peculiar to one or more, but not all of the QS Series Power Supplies. Thus, the value of a component so identified in the following complete parts list for the Model QS 40 Power Supply may change from one power supply to another in the QS Series, as indicated in the "PARTS PECULIAR" tabulations contained in the rear portion of this table.		
		Model QS 40 Power Supply	1	04746
C1*	2004642-4	. CAPACITOR, FXD, ELEC, 3000 mfd, 75 wvdc	1	04746
C2*	TTM-44-75	. CAPACITOR, FXD, ELEC, 44 mfd, 75 wvdc	1	06124
C3,C5, C6	DF104	. CAPACITOR, FXD, CERAMIC, .1 mfd, 600 wvdc	3	71590
C4*	TCW-500-75	. CAPACITOR, FXD, ELEC, 500 mfd, 75 wvdc	1	06124
CR1*	3SCBR1	. RECTIFIER ASSY	1	04746
DS1	BG03-RC-B-NE2H-33K	. LAMP, INDICATOR, red	1	03797
F1	31301-5	. FUSE, CARTRIDGE, 1.5 amp (3AG slo-blo).	1	75915
J1	DF21WTC	. POST, BINDING, white.	1	58474
J2	DF21BC	. POST, BINDING, black	1	58474
J3	DF21RC	. POST, BINDING, red	1	58474
M1*	4005433-4	. VOLTMETER, 0-40 vac scale	1	04746
M2*	4005433-4	. AMMETER, 0-1.5 amp scale	1	04746
Q1*		Not Used		
Q2,Q3*	2N3055	. TRANSISTOR, silicon, NPN	2	95445
R1	2004639	. RESISTOR, power tapped, 2 ohms max, ±5%, 10w at 85°C.	1	04746
R2*	2004641	. RESISTOR, power tapped, 0.4 ohm max, ±5%, 2.6w at 85°C	1	04746
R3A,R3B*	1400235-4	. POTENTIOMETER, DUAL, CONCENTRIC, 4.25K ohms outer shaft, 100 ohms inner shaft, 2w	1	04746
R4	39929	. POTENTIOMETER, WW, 200 ohms, 2w .	1	71450

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
S1	MST105D	. SWITCH, TOGGLE, SPDT	1	95146
T1*	3004727	. TRANSFORMER, POWER, STEP-DOWN .	1	04746
TB1	351-28-11-001	. TERMINAL BOARD, 11 term.	1	71785
	73150	. JUMPER, terminal board	3	83330
XF1	4405	. FUSEHOLDER	1	03614
*	4004675-4	. PRINTED CIRCUIT BOARD ASSY (See breakdown below)	1	04746
	2004609	. HEATSINK	1	04746
	0-1803-076GY	. POWER CORD	1	70903
	4004675-4	Printed Circuit Board Assy	Ref	04746
C101	NLW-20-50	. CAPACITOR, FXD, ELEC, 20 mfd, 50 wvdc	1	09023
C102, C103	BR250-50	. CAPACITOR, FXD, ELEC, 250 mfd, 50 wvdc	2	09023
C104	SP021-4393	. CAPACITOR, FXD, ELEC, 100 mfd, 75 wvdc	1	76149
C105	NLW-50-50	. CAPACITOR, FXD, ELEC, 50 mfd, 50 wvdc	1	09023
C106	801X5R221K	. CAPACITOR, DISC, CERAMIC, 220 pf, 500 wvdc.	1	18796
C107, C108	NLW-25-15	. CAPACITOR, FXD, ELEC, 25 mfd, 15 wvdc	2	09023
C109*	CM15E471J	. CAPACITOR, FXD, PAPER, 470 pfd, 500 wvdc	1	02799
C111	P95ZN	. CAPACITOR, FXD, PAPER, 0.02 mfd, ±20%, 200 wvdc	1	00656
C112	210B1C224	. CAPACITOR, FXD, MYLAR, 0.22 mfd, ±20%, 200 wvdc	1	14752
CR101	FWL100	. RECTIFIER ASSY	1	76149
CR102, CR108, CR111	ZA8.2B	. SEMICONDUCTOR DEVICE, DIODE, Zener diode	3	76149
CR103, CR106*		Not Used		
CR104	VB100	. RECTIFIER ASSY	1	76149
CR105, CR109, CR110, CR112	DI22AA	. SEMICONDUCTOR DEVICE, DIODE . . .	4	04746

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
CR107	1N936	. SEMICONDUCTOR DEVICE, DIODE, Zener diode	1	04713
CR113*	2300005-3	. SEMICONDUCTOR DEVICE, DIODE	1	04746
Q101, Q102	2N3053	. TRANSISTOR	2	95445
Q103 thru Q107, Q109, Q110	SN22AA	. TRANSISTOR	7	04746
Q108	SP22AA	. TRANSISTOR	1	04746
R101*		Not Used		
R102	RC42GF511J	. RESISTOR, FXD, COMP, 510 ohms ±5%, 2w	1	81349
R103*	RC32GF272J	. RESISTOR, FXD, COMP, 2.7K ohms ±5%, 1w	1	81349
R104	RC42GF301J	. RESISTOR, FXD, COMP, 300 ohms ±5%, 2w	1	81349
R105,R107	RC20GF621J	. RESISTOR, FXD, COMP, 620 ohms ±5%, 1/2w	2	81349
R106	RC20GF104J	. RESISTOR, FXD, COMP, 100K ohms ±5%, 1/2w	1	81349
R108,R136	RC20GF102J	. RESISTOR, FXD, COMP, 1K ohms ±5%, 1/2w	2	81349
R109,R115	RN65C1471F	. RESISTOR, METAL FILM, (T-2) (50 ppm), 1.47K ohms ±1%, 1/2w	2	81349
R110,R112	RN65D6041F	. RESISTOR, METAL FILM, 6.04K ohms ±1%, 1/2w	2	81349
R111	RN65D4021F	. RESISTOR, METAL FILM, 4.02K ohms ±1%, 1/2w	1	81349
R113	RN65C1021F	. RESISTOR, METAL FILM, (T-2) (50 ppm), 1.02K ohms ±1%, 1/2w	1	81349
R114,R123	RN65D	. RESISTOR, METAL FILM (value selected in test)	2	81349
R116	RC20GF335J	. RESISTOR, FXD, COMP, 3.3 megohm, ±5%, 1/2w	1	81349
R117	RN65D1003F	. RESISTOR, METAL FILM, 100K ohms ±1%, 1/2w	1	81349
R118,R122, R134	RN65D1001F	. RESISTOR, METAL FILM, 1K ohms ±1%, 1/2w	1	81349

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES (Continued)

REF DES	PART NO.	1	2	3	4	DESCRIPTION	QTY	MFR CODE
R119,R121	RN65D9091F	.				RESISTOR, METAL FILM, 9.09K ohms ±1%, 1/2w	2	81349
R120	RN65D3831F	.				RESISTOR, METAL FILM, 3.83K ohms ±1%, 1/2w.	1	81349
R124	50AP	.				RESISTOR, FXD, WW, 2K ohms ±0.1%, 1/2w.	1	06416
R125	RC20GF513J	.				RESISTOR, FXD, COMP, 51K ohms ±5%, 1/2w	1	81349
R126	RC20GF103J	.				RESISTOR, FXD, COMP, 10K ohms ±5%, 1/2w	1	81349
R127,R130	RC20GF222J	.				RESISTOR, FXD, COMP, 2.2K ohms ±5%, 1/2w	2	81349
R128	RC20GF101J	.				RESISTOR, FXD, COMP, 100 ohms ±5%, 1/2w	1	81349
R129,R131	RC20GF392J	.				RESISTOR, FXD, COMP, 3.9K ohms ±5%, 1/2w	2	81349
R132*	RN65D5230F	.				RESISTOR, METAL FILM, 523 ohms ±1%, 1/2w	1	81349
R133	3067P-1-103	.				POTENTIOMETER, 10K ohms	1	80294
R135*	RN65D4022F	.				RESISTOR, METAL FILM, 40.2K ohms ±1%, 1/2w	1	81349
R137*		Not Used						
	05-0803	.				SOCKET, TRANSISTOR	7	91662
XQ101, XQ102, XQ108	05-3304	.				SOCKET, TRANSISTOR	3	91662
	NF207	.				HEATSINK	2	05820

PARTS PECULIAR TO MODEL QS 5 POWER SUPPLY

C1	2004642-1	.				CAPACITOR, FXD, ELEC, 9,300 mfd, 20 wvdc	1	04746
C2	TTM-188-20	.				CAPACITOR, FXD, ELEC, 188 mfd, 20 wvdc	1	06124
C4	TCW-2000-20	.				CAPACITOR, FXD, ELEC, 2000 mfd, 20 wvdc	1	06124
CR1	2AFB1AP	.				RECTIFIER ASSY	1	81483
M1	4005433-1	.				VOLTMETER, 0-5 vac scale	1	04746
M2	4005433-1	.				AMMETER, 0-7 amp scale	1	04746

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
Q1	40250	. TRANSISTOR, silicon, NPN	1	95445
Q2,Q3	2N3055	. TRANSISTOR, silicon, NPN	2	95445
R2	2004641	. RESISTOR, power tapped, 0.4 ohm max, ±5%, 2.6w at 85°C	1	04746
R3A,R3B	1400235-1	. POTENTIOMETER, DUAL, CONCENTRIC, 530 ohms outer shaft, 100 ohms inner shaft, 2w	1	04746
T1	3004724	. TRANSFORMER, POWER, STEP DOWN .	1	04746
	4004675-1	. PRINTED CIRCUIT BOARD ASSY (See breakdown below)	1	04746
	4004675-1	Printed Circuit Board Assy	Ref	04746
C109	DD152	. CAPACITOR, FXD, CERAMIC, .0015 mfd ±20%, 1 KV	1	71590
CR103, CR106	D122AA	. SEMICONDUCTOR DEVICE, DIODE . . .	2	04746
CR113		Not Used		
R101	RC32GF272J	. RESISTOR, FXD, COMP, 2.7K ohms ±5%, 1w	1	81349
R103	RC20GF122J	. RESISTOR, FXD, COMP, 12K ohms ±5%, 1/2w	1	81349
R132	RN65D6340F	. RESISTOR, METAL FILM, 634 ohms ±1%, 1/2w	1	81349
R135	RN65D4871F	. RESISTOR, METAL FILM, 4.87K ohms ±1%, 1/2w	1	81349
R137	RC20GF221J	. RESISTOR, FXD, COMP, 220 ohms ±5%, 1/2w	1	81349

PARTS PECULIAR TO MODEL QS 10 POWER SUPPLY

C1	2004642-2	. CAPACITOR, FXD, ELEC, 8,500 mfd, 30 wvdc	1	04746
C2	TTM-141-25	. CAPACITOR, FXD, ELEC, 141 mfd, 25 wvdc	1	06124
C4	TCW-1500-25	. CAPACITOR, FXD, ELEC, 1500 mfd, 25 wvdc.	1	06124
CR1	2AFB1AP	. RECTIFIER ASSY	1	81483
M1	4005433-2	. VOLTMETER, 0-10 vac scale	1	04746

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
M2	4005433-2	. AMMETER, 0-5 amp scale	1	04746
Q1	40250	. TRANSISTOR, silicon NPN	1	95445
Q2,Q3	2N3055	. TRANSISTOR, silicon NPN	2	95445
R2	2004641	. RESISTOR, power tapped, 0.4 ohm max ±5%, 2.6w at 85°C	1	04746
R3A,R3B	1400235-2	. POTENTIOMETER, DUAL, CONCENTRIC, 1100 ohms outer shaft, 100 ohms inner shaft, 2w	1	04746
T1	3004725	. TRANSFORMER, POWER, STEP-DOWN .	1	04746
	4004675-2	. PRINTED CIRCUIT BOARD ASSY (See breakdown below)	1	04746
	4004575-2	Printed Circuit Board Assy	Ref	04746
C109	DD152	. CAPACITOR, FXD, CERAMIC, .0015 mfd ±20%, 1 KV	1	71590
CR103, CR106	D122AA	. SEMICONDUCTOR DEVICE, DIODE . . .	2	04746
CR113		Not Used		
R101	RC32GF272J	. RESISTOR, FXD, COMP, 2.7K ohms ±5%, 1w.	1	81349
R103	RC20GF122J	. RESISTOR, FXD, COMP, 12K ohms ±5%, 1/2w	1	81349
R132	RN65D9310F	. RESISTOR, METAL FILM, 931 ohms ±1%, 1/2w.	1	81349
R135	RN65D1002F	. RESISTOR, METAL FILM, 10K ohms ±1%, 1/2w	1	81349
R137	RC20GF221J	. RESISTOR, FXD, COMP, 220 ohms ±5%, 1/2w	1	81349

PARTS PECULIAR TO MODEL QS 20 POWER SUPPLY

C1	2004642-3	. CAPACITOR, FXD, ELEC, 5,000 mfd, 50 wvdc	1	04746
C2	TTM-79-40	. CAPACITOR, FXD, ELEC, 79 mfd, 40 wvdc.	1	06124
C4	TCW-750-40	. CAPACITOR, FXD, ELEC, 750 mfd, 40 wvdc	1	06124
CR1	2AFB1AP	. RECTIFIER ASSY	1	81483

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
M1	4005433-3	. VOLTMETER, 0-20 vac scale	1	04746
M2	4005433-3	. AMMETER, 0-3 amp scale	1	04746
Q1	40250	. TRANSISTOR, silicon, NPN	1	95445
Q2,Q3	2N3055	. TRANSISTOR, silicon, NPN	1	95445
R2	2004641	. RESISTOR, power tapped, 0.4 ohm max, ±5%, 2.6w at 85°C	1	04746
R3A,R3B	1400235-3	. POTENTIOMETER, DUAL, CONCENTRIC, 2150 ohms outer shaft, 100 ohms inner shaft, 2w	1	04746
T1	3004726	. TRANSFORMER, POWER, STEP-DOWN	1	04746
	4004675-3	. PRINTED CIRCUIT BOARD ASSY (See breakdown below)	1	04746
	4004675-3	Printed Circuit Board Assy	Ref	04746
C109	DD152	. CAPACITOR, FXD, CERAMIC, .0015 mfd ±20%, 1 KV	1	71590
CR103, CR106	DI22AA	. SEMICONDUCTOR DEVICE, DIODE	2	04746
CR113		Not Used		
R101	RC32GF272J	. RESISTOR, FXD, COMP, 2.7K ohms ±5%, 1w	1	81349
R103	RC20GF122J	. RESISTOR, FXD, COMP, 12K ohms ±5%, 1/2w	1	81349
R132	RN65D1131F	. RESISTOR, METAL FILM, 1.13K ohms ±1%, 1/2w	1	81349
R135	RN65D2002F	. RESISTOR, METAL FILM, 20K ohms ±1%, 1/2w	1	81349
R137	RC20GF221J	. RESISTOR, FXD, COMP, 220 ohms ±5%, 1/2w.	1	81349

PARTS PECULIAR TO MODEL QS 60 POWER SUPPLY

C1	2004642-5	. CAPACITOR, FXD, ELEC, 1,800 mfd, 125 wvdc	1	04746
C2	TTM-28-125	. CAPACITOR, FXD, ELEC, 28 mfd, 125 wvdc	1	06124
C4	TCW-300-125	. CAPACITOR, FXD, ELEC, 300 mfd, 125 wvdc.	1	06124

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
CR1	3SCBR4	. RECTIFIER ASSY	1	14099
M1	4005433-5	. VOLTMETER, 0-60 vac scale	1	04746
M2	4005433-5	. AMMETER, 0-1.0 amp scale	1	04746
Q1		Not Used		
Q2,Q3	2N3442	. TRANSISTOR, silicon, NPN	1	95445
R2	2004639	. RESISTOR, power tapped, 2 ohms max, ±5%, 10w at 85°C	1	04746
R3A,R3B	1400235-5	. POTENTIOMETER, DUAL, CONCENTRIC, 6250 ohms outer shaft, 100 ohms inner shaft, 2w	1	04746
T1	3004728	. TRANSFORMER, POWER, STEP-DOWN .	1	04746
	4004675-5	. PRINTED CIRCUIT BOARD ASSY (See breakdown below)	1	04746
	4004675-5	Printed Circuit Board Assy	Ref	04746
C109	CM15E-471J	. CAPACITOR, FXD, MICA, 470 pf, 500 wvdc.	1	02799
CR103, CR106		Not Used		
CR113	D122AA	. SEMICONDUCTOR DEVICE, DIODE . .	1	04746
R101		Not Used		
R103	RC32GF272J	. RESISTOR, FXD, COMP, 2.7K ohms ±5%, 1w	1	81349
R132	RN65D1911F	. RESISTOR, METAL FILM, 1.91K ohms ±1%, 1/2w	1	81349
R135	RN65D6042F	. RESISTOR, METAL FILM, 60.4K ohms ±1%, 1/2w	1	81349
R137		Not Used		

PARTS PECULIAR TO MODEL QS 100 POWER SUPPLY

C1	2004642-6	. CAPACITOR, FXD, ELEC, 1,150 mfd, 175 wvdc.	1	04746
C2	TCM-5-175	. CAPACITOR, FXD, ELEC, 5 mfd, 175 wvdc	1	06124
C4	TC-117-175	. CAPACITOR, FXD, ELEC, 117 mfd, 175 wvdc	1	14655

TABLE 5-1. PARTS LIST FOR QS SERIES DC POWER SUPPLIES (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
CR1	3SCBR4	. RECTIFIER ASSY	1	14099
M1	4005433-6	. VOLTMETER, 0-100 vac scale	1	04746
M2	4005433-6	. AMMETER, 0-0.7 amp scale.	1	04746
Q1		Not Used		
Q2,Q3	2N3442	. TRANSISTOR, silicon, NPN	2	95445
R2	2004639	. RESISTOR, power tapped, 2 ohms max, ±5%, 10w at 85°C.	1	04746
R3A,R3B	1400235-6	. POTENTIOMETER, DUAL, CONCENTRIC, 10.6K ohms outer shaft, 100 ohms inner shaft, 2w	1	04746
T1	3004729	. TRANSFORMER, POWER, STEP-DOWN .	1	04746
	4004675-6	. PRINTED CIRCUIT BOARD ASSY (See breakdown below)	1	04746
	4004675-6	Printed Circuit Board Assy	Ref	04746
C109	CM15E-471J	. CAPACITOR, FXD, MICA, 470 pf, 500 wvdc.	1	02799
CR103, CR106		Not Used		
CR113	D122AA	. SEMICONDUCTOR DEVICE, DIODE . . .	1	04746
R101		Not Used		
R103	RC32GF272J	. RESISTOR, FXD, COMP, 2.7K ohms ±5%, 1w	1	81349
R132	RN65D1331F	. RESISTOR, METAL FILM, 1.33K ohms ±1%, 1/2w.	1	81349
R135	RN65D1003F	. RESISTOR, METAL FILM, 100K ohms ±1%, 1/2w	1	81349
R137		Not Used		

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